ELECTRONICS for MODEL RAILWAYS

BOOK 2

$3.80
$5.00NZ incl GST

By Ken Stone

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- Level Crossing Lights
- Economy Power Supply
- Signals
- Tunnel Stretcher & Station Signal
- Computers and Model Railways
- Delay Module
- Walk-Around Throttle
- Servo Controller
- Diesel Sound Generators
- Simple PWM Throttle
- Fibre Optics

A TALKING ELECTRONICS PUBLICATION

KITS FOR THIS BOOK

All the projects in this book are available in kit-form. Both the writer and producers of this book are hobbyists and know what's it's like to be faced with high prices for parts and equipment, that's why all the kits are reasonably priced and guaranteed to be available for the next 10 years! This is the second book in the series and you will find the kits for our first book on the back cover. These kits are enormously popular, six years after the book 1 was released! We are sure this book will be just as popular as these projects are so effective when added to your layout.

Dedicated Microcomputer Mk II & PC $54.40
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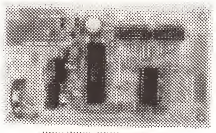
A great way to start in microcomputer controllers. This kit comes complete with an EPROM programmed with the latest tri-function software.



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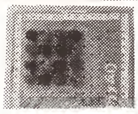

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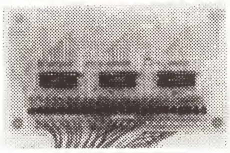

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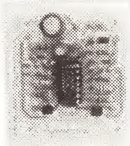
This project is a universal building block for use with the DMS or other control and timing circuits.



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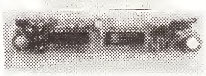

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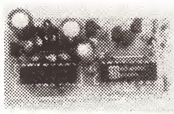

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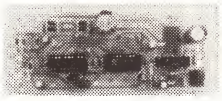

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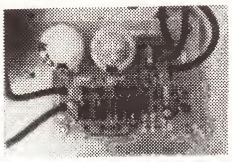

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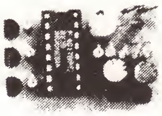

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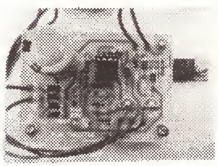

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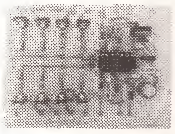

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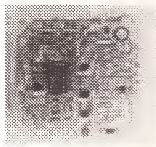
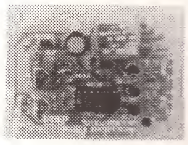
A simple "universal" signal module that can be used in a number of ways, including 2 and 3 aspect.



Tunnel Stretcher & PC $14.15
PC board only $3.50
Use it as a station signal, or to "extend" your layout.



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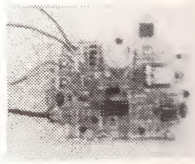
PC board only $ 5.75
A true wireless walk-around throttle using a commercial radio control set. No more tripping over wires!



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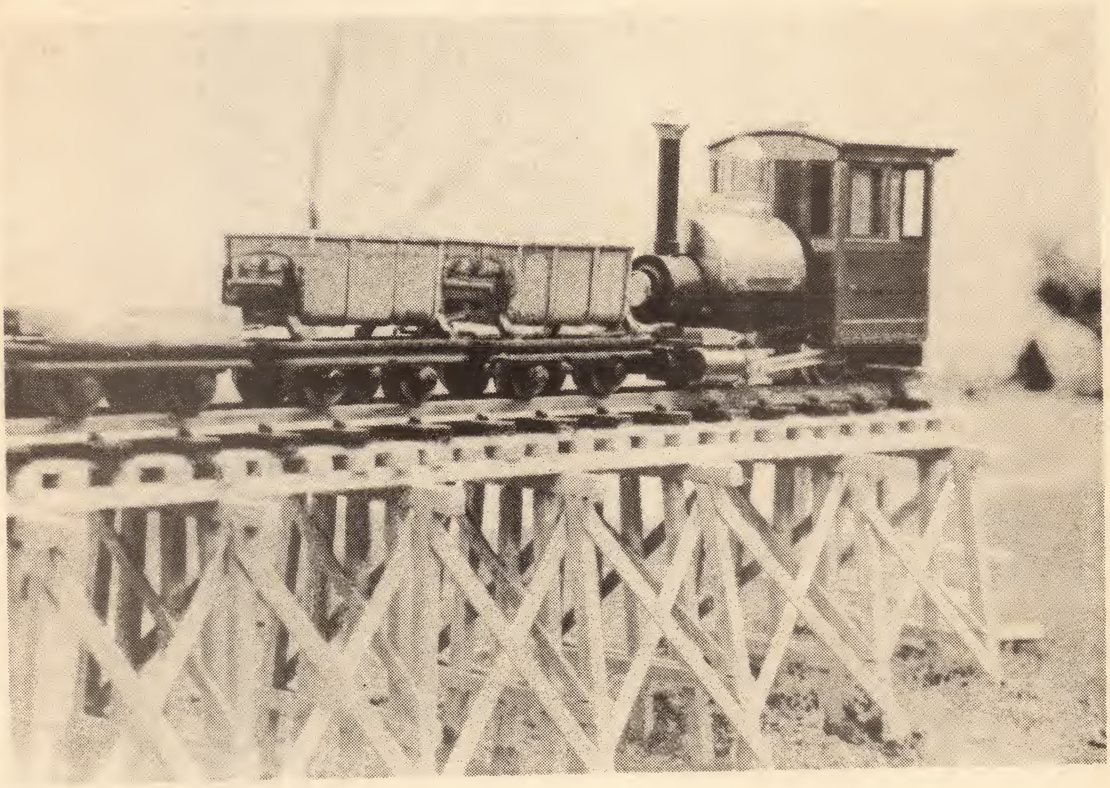
ELECTRONICS

FOR

MODEL RAILWAYS

BOOK 2

By Ken Stone



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INTRODUCTION

It has been a while since I wrote the first volume of Electronics for Model Railways, and when I finished it, I found I had a couple of projects left over. These were set aside with the idea of perhaps producing a second book at a later date. The ideas were there, and luckily some documentation, too, because now that I'm actually writing the second volume, it has made my job just that little bit easier.

Why had it taken me so long? Well, not long after I finished writing the first book, I found myself a new job in industry, designing and manufacturing computer controlled warning signs, much like the tiny one I described in the last book. From there I moved into designing standby power supplies for computers, and had my first chance to use a real computer. Over the next three years, I learnt how to drive CAD packages and word processors, as well as learning a few tricks of the trade. Ultimately, armed with the new skills, I have returned to my favorite job, writing books and magazines on electronics.

Often a modeller is scared away from electronics by unreasonable prices. Some people think that it is easy to rip off the uninformed, doing things like pricing fifteen cent power diodes at six dollars each. No one wins when this is done. The modeller learns to fear electronics, and refuses to buy anything, and the person who was hoping to get rich quick stays just as poor.

With the backing of Talking Electronics, I am able to present circuits that can add enjoyment and realism to any model railway. Printed circuit boards and kits are available for the projects too, all at reasonable prices.

The projects cover a range of skill levels too. There is a simple level crossing flasher that even beginners will find easy to build. At the other end of the scale, there is another project for the little microcomputer from the last book. While this project is fairly complex, it is one of my favorites. Instead of driving only a set of traffic lights, it now does two extra things as well. It will automatically turn on your street lights when it gets dark, simulating fluorescent lamps starting while doing so. It also will drive a miniature advertising sign made of a four by four matrix of LEDs. If you want someone to look at your layout, this thing will catch their attention for you! It is so effective that I have used it for real advertising.

Most of the other circuits are limited to one or two chips to keep them simple. Once again I have made use of what I feel is the most versatile chip on the market, the CMOS 40106 Hex Schmitt Inverter. The things I have done with this chip range from simple flashers and delays, right up to an experimental automotive voltage regulator.

For those who like experimenting, I have also presented a radio controlled throttle. It uses a commercially available radio control set to allow true wireless, walk-around control of the throttle. The circuit is based on that of a very successful radio controlled car speed controller that I designed. There are a few hundred of these almost indestructible things running around the country in 1/10th scale off road vehicles!

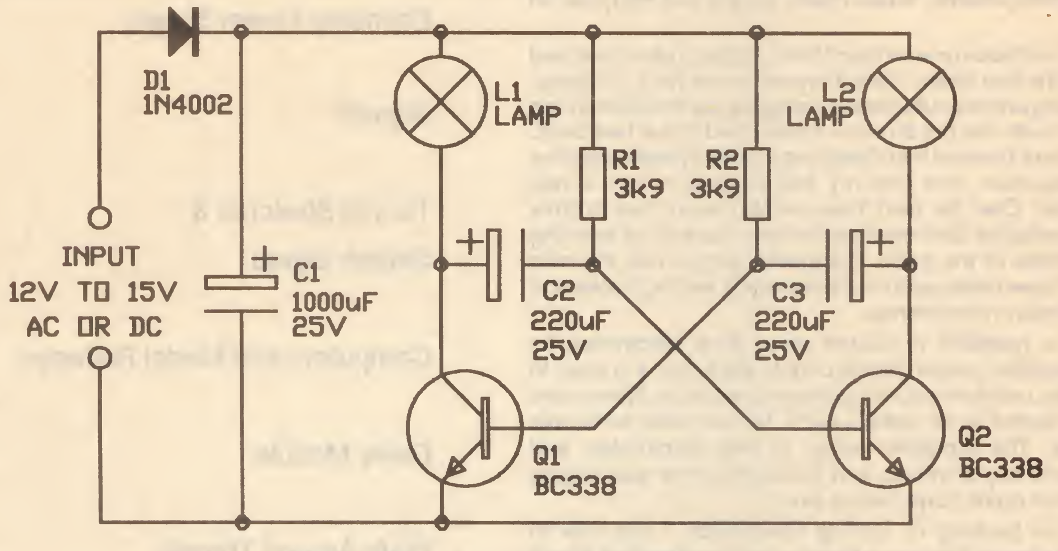
Well, I think I've said enough, so on with the book. Try a couple of the projects. You'll enjoy them. For those who aren't too familiar with electronics, read all the articles. Some of the earlier ones go into detailed explanations for beginners, while later ones assume you are familiar with the terms used.

Ken

INDEX

LEVEL CROSSING LIGHTS

Every model railway has a place where road and rail meet, and where it does, some form of warning is needed. Flashing lights work well, but something is needed to drive them. And that is where this circuit comes in. All it does is flash lights, and it is so simple anyone could build it!



LEVEL CROSSING CIRCUIT.

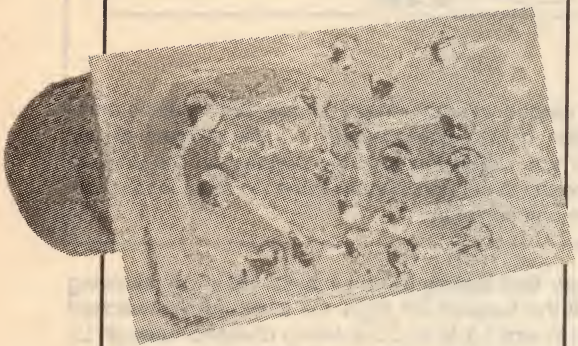
Its beauty is in its simplicity. Apart from the lamps, there are only eight components. Behind the simplicity of the transistor multivibrator is an ingenious design. The details of how it works are given in the text.

Often the first electronic accessory added to a model railway is the circuit used to drive the flashing lights at a level crossing. And that is because without electronics, crossing lights cannot be made to operate. I know, it was the first circuit I attempted as a youngster, for my model railway. The first one I built used three ex-PMG slow release relays, making it somewhat cumbersome and very noisy. I had seen one like it at an exhibition, and bought the relays on the spot. Back at home, with soldering iron in hand, it took me several hours to work out the switching circuit, but I eventually did. There was one major problem with it. It was simply too big to hide on the layout. It was eventually banished to switching Christmas tree lights. Of course a simple transistor multivibrator would have done the job just as easily, without either the space or noise problems.

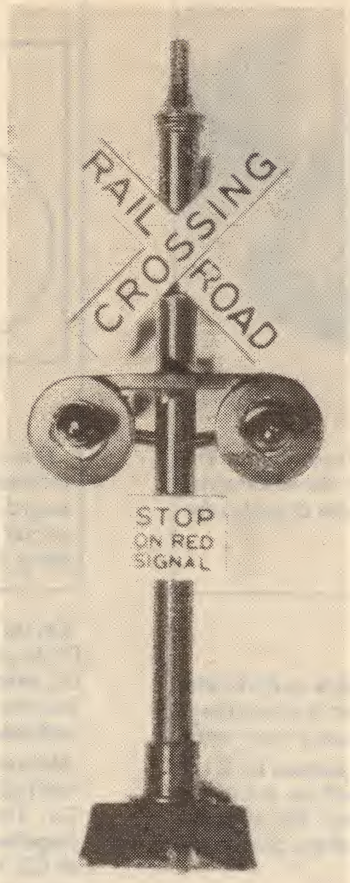
These photographs show the true simplicity of construction. The printed circuit board holds all eight components required to make the level crossing lamp flasher. The lamps themselves are the final components required to make this tiny module work.

This is a commercial set of level crossing lights. The ones sold as being HO scale are really a bit over-scale. The N scale ones are just about the right size for using on HO. Most real level crossings use more than two sets of flashing lights, but due to the cost of scale crossing lights, modellers often limit their crossings to just two.

If you look closely at the photograph, you will notice that the lamps can be seen from both sides of the sign. Painting the back of the lamp helps reduce the light visible from behind.



If this is the first project you have built, take special care with the soldering. When you have finished, this is what the back of the board should look like. Don't expect it to work if there are solder bridges and dry joints. These two soldering faults, along with incorrectly placed components, are the biggest cause of projects not working properly. Rarely is it actually a faulty component.



PARTS LIST

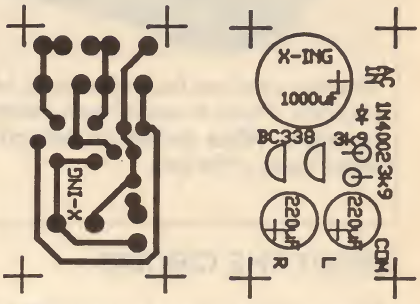
2- 3k9 1/4 resistors

2- 220uF 25V electrolytics
1- 1000uF 25V electrolytic

1- 1N4002 Diode

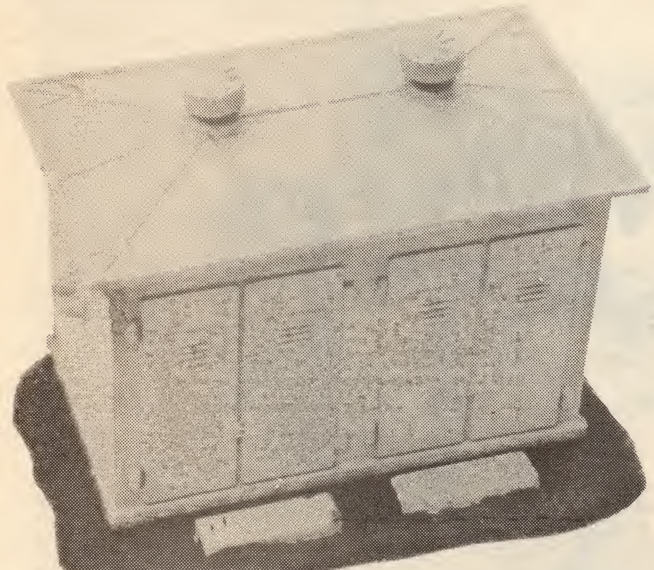
2- BC338 Transistors

1- Crossing PCB (X-ING)



Construction of the actual PCB is possible if you wish to use this artwork. However, due to the amount of effort that is needed to make your own printed circuit boards, it is both easier and cheaper to buy a ready made one from a kit supplier.

I never make my own boards, preferring to have even prototypes professionally etched. The result is always a lot neater and more reliable.

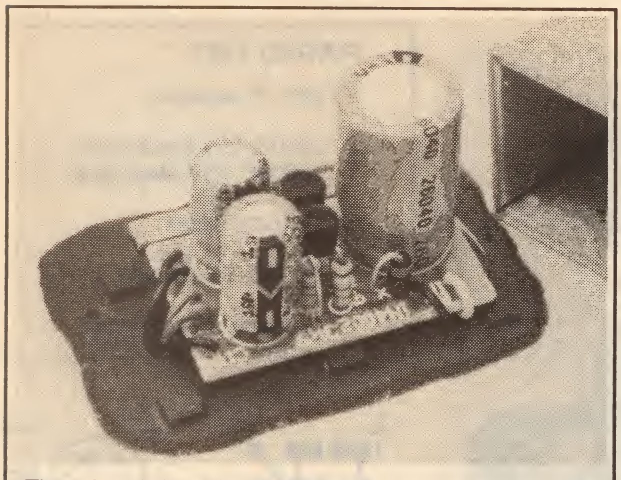


This is the plastic relay box in which I mounted my crossing lamp flasher. It came in a kit that contained a maintenance shed, a track inspection car, and an assortment of small tools.

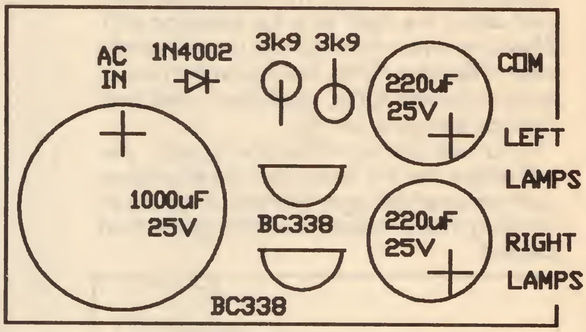
In Electronics for Model Railways volume #1, I presented a fully automatic level crossing circuit capable of handling multi-track crossings. It featured an electronic twin bell sound generator, and if required, was capable of opening and closing motorized boom gates. It used four printed circuit boards, allowing it to be configured to various layouts. While I still think that it is a great project, some people are daunted by its complexity. All they want is a simple circuit to flash the lights.

So this time I am presenting a circuit from the opposite end of the scale. It uses only eight components, all of them cheap and is very easy to build, making it an ideal beginners project. And all it does is flash lights. Switching it on and off must be done either by another circuit, or a simple switch.

It is a completely stand alone project. It runs directly off the 12V to 15V AC or DC accessory outputs provided on the back of some train controllers, making it unnecessary to build a special power supply. The whole unit is small enough to be built into a track-side shed or relay box, making it very easy to hide on your layout. If you refer to the photographs, you will see the plastic relay box in which I installed mine.



The printed circuit board fits nicely into the bottom of the relay box. There is ample room inside for the electrolytic capacitors. Wires can be run through a hole drilled in the plastic base of the box.



This enlarged overlay clearly shows the location and orientation of the components on the printed circuit board. If you follow this and the overlay on the printed circuit board itself, you should have no trouble assembling the unit correctly.

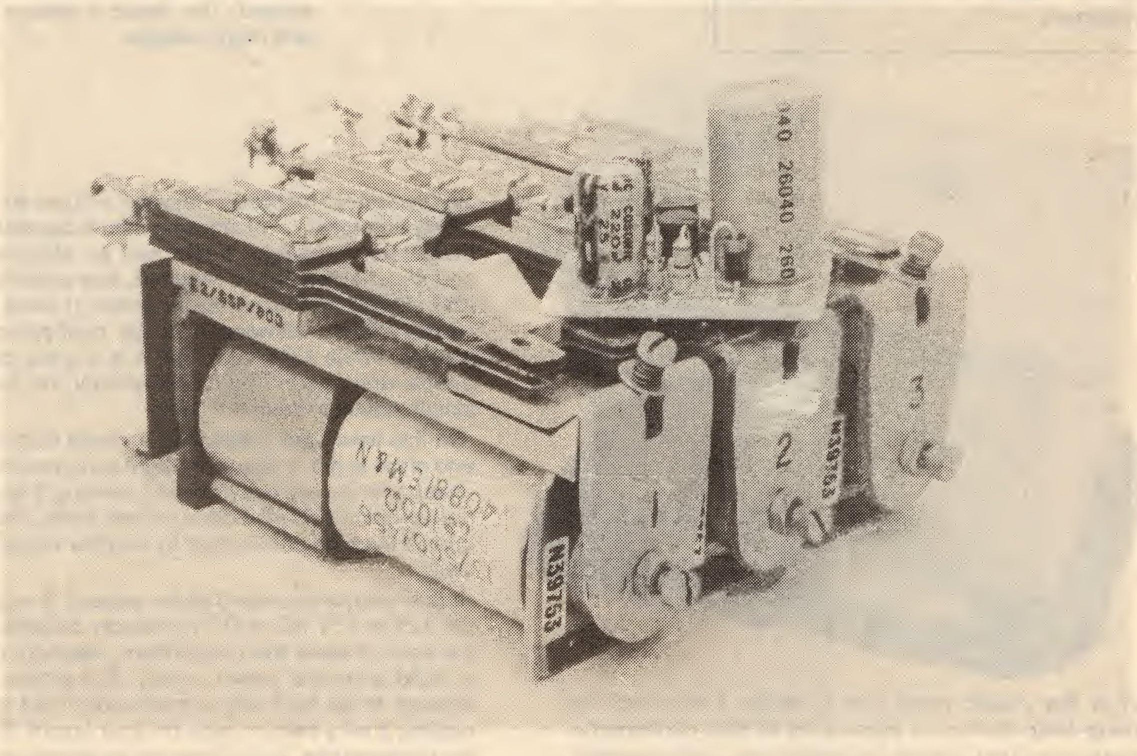
ABOUT THE CIRCUIT

The circuit is simply a two transistor astable multivibrator fed by a half wave rectifier. The lamps form the outer legs of the circuit. Without the lamps in the circuit, it won't work.

Only the positive half cycle of the AC is passed by D1. It charges the 1000uF capacitor C1 as well as supplying power to the rest of the circuit. Then when the negative half cycle is being blocked by D1, the rest of the circuit runs off the charge held in C1.

Let us say that initially lamp L1 is lit. Q2 is off, allowing R2 to pull the base of Q1 high. Q1 is therefore switched on, which is why L1 is lit. C3 is being charged through L2 and the base-emitter junction of Q1. A single lamp when switched off, is about thirty ohms (30R).

Meanwhile, C2, which was charged last time Q2 was on, has had its positive end pulled down to about 0.3 volts by Q1. This means that the other end of C2 is actually negative with respect to the zero volt rail and the emitter of Q2. C2 is now discharged by R1. In fact R1 is really trying to charge the capacitor the other way around! This



The old meets the new. The ex-PMG relays dwarf the tiny printed circuit board.

will continue until the negative end of C2 reaches about 0.6 volts taking the base of Q2 with it. At this point, Q2 will turn on and lamp L2 will light. It will also pull the positive end of C3 to about 0.3 volts. As C3 is now holding a charge of 12 to 15 volts, the negative end of it will be 12 to 15 volts below the zero volt rail. Thus the base of Q1 will also be at this negative potential, meaning that Q1 is now very definitely switched off. Lamp L1 will extinguish.

The whole process will now repeat itself, except the other way around. When the negative end of C3 reaches 0.6 volts, Q1 will again switch on, switching Q2 off. This "battle" will continue until the power is switched off.

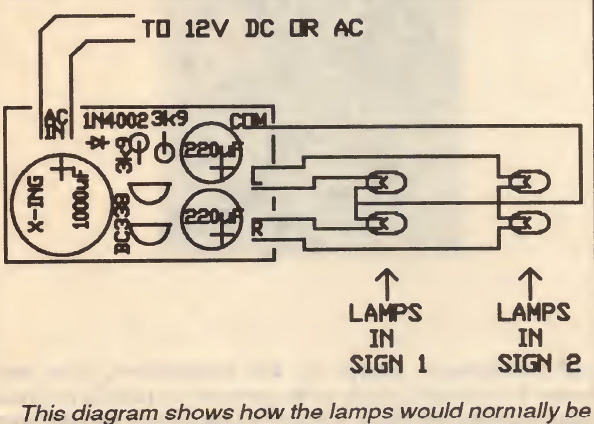
The circuit's behavior depends on the power supply used, and the number or lamps connected to it. Varying the number of lamps will change the flash rate. Changing the supply voltage also effects it. If you have the choice of either AC or DC, connecting it to the DC supply will give better results. As some train controllers don't even mark the positive and negative terminals, you will have to try it out to find the right way to connect it. If nothing happens when you first connect it, reverse the connections and try again. You cannot damage the circuit if you get it backwards as D1 will block the DC and protect the components.

If you find the lamp brightness too great, there are three possible solutions. The first is to reduce the voltage to the unit. If you can't do that, try running your lamps in series.

Refer to the diagram opposite to see how this is done. This will only work properly if all of the lamps are of the same type. If they are not, you will have to use the third method, and that is to put a resistor in line with each pair of lamps. The value of the resistor should be either 10R or 22R.

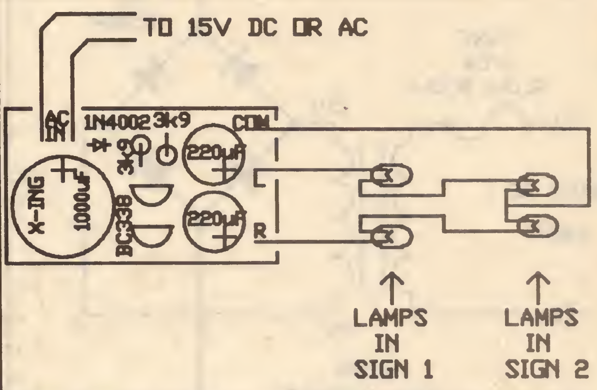
CONSTRUCTION

Construction is quite simple as there are only eight components. The resistors and diode have all been stood on end to save space. Take particular care with the orientation of the diode. It is very easy to solder a diode in backwards when it is stood on end. The orientation of the capacitors is also critical. If you put one in backwards, at best the circuit will not function correctly, the lamps fading in and out or just staying either on or off, at worst, you'll spend the next hour wiping electrolyte from the walls.

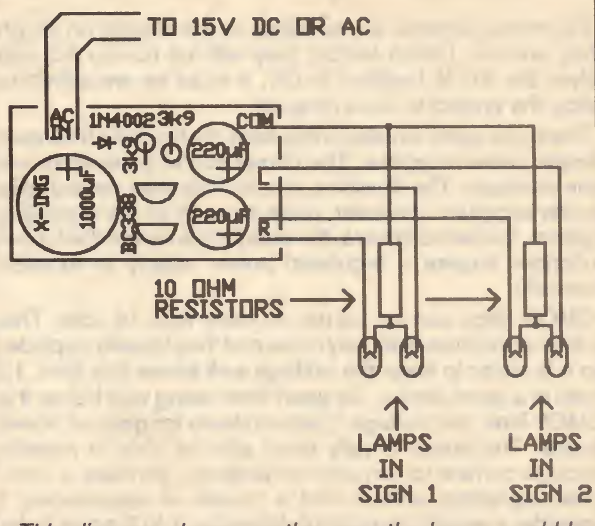


This diagram shows how the lamps would normally be wired. Each lamp from one crossing sign is parallelled with the corresponding lamp in the other sign. All four lamps share the same common wire. If one lamp blows, the circuit will continue to work.

Refer to the diagrams for the way to wire the lamps to the board. As mentioned earlier, the board is small enough to fit into a track-side hut if it is impractical for you to mount it under the layout. Just keep the wires tidy. On my old HO layout (the one I built as a youngster), I used to make fences out of my wiring. Using match sticks as posts, I would run fine enamelled winding wire between them. The fences didn't look bad, and it sure beat trying to hide the wires on the flat sheet of chipboard. In those days I wasn't allowed to make scenery from plaster, or anything else for that matter, so it was a case of making the best of what I had. As you won't have these restrictions, your efforts will undoubtedly be neater.



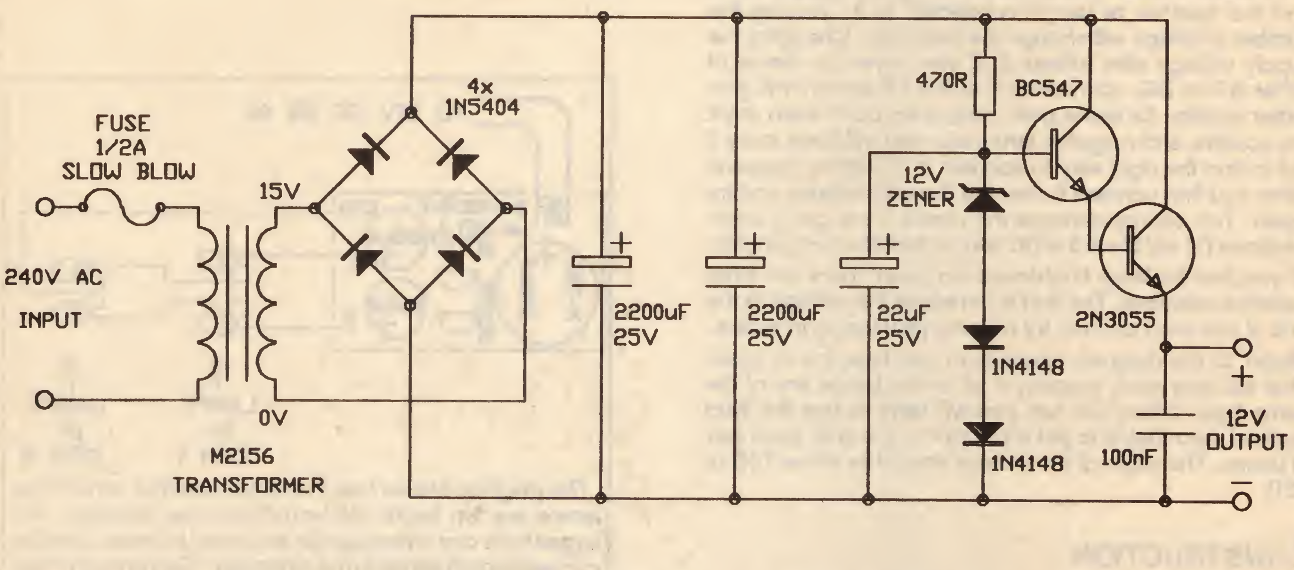
This diagram shows how the lamps could be wired if the lamps are too bright. All lamps must be identical. The lamps from one crossing sign are wired in series with the corresponding lamps in the other sign. Each string of two lamps is taken to the board common. If one lamp blows, the circuit will stop working.



This diagram shows another way the lamps could be wired if they are too bright. The circuit is similar to the first diagram, except for the addition of a resistor in line with the common return from each sign. The resistors should be 10 to 22 ohms depending on the lamps used. Start with 10R resistors. If it is still too bright, replace them with 22R resistors. If one lamp blows, the circuit will continue to work.

ECONOMY POWER SUPPLY

Electronic projects require smoothed, regulated power to function correctly. The DC output available from the auxiliary outputs of a train controller is neither, making it unsuitable. This simple project will provide power for many accessories without breaking the bank, so you can spend more on your real interest, trains.

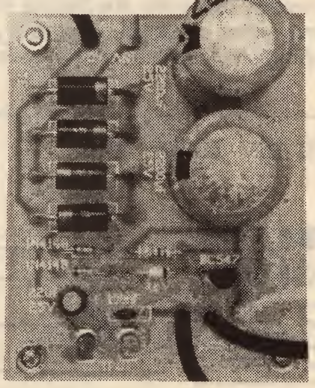


Using only readily available components, this simple power supply is capable of delivering up to two amps, depending on the transformer selected. With a two amp transformer, the output will be about one and a half amps.

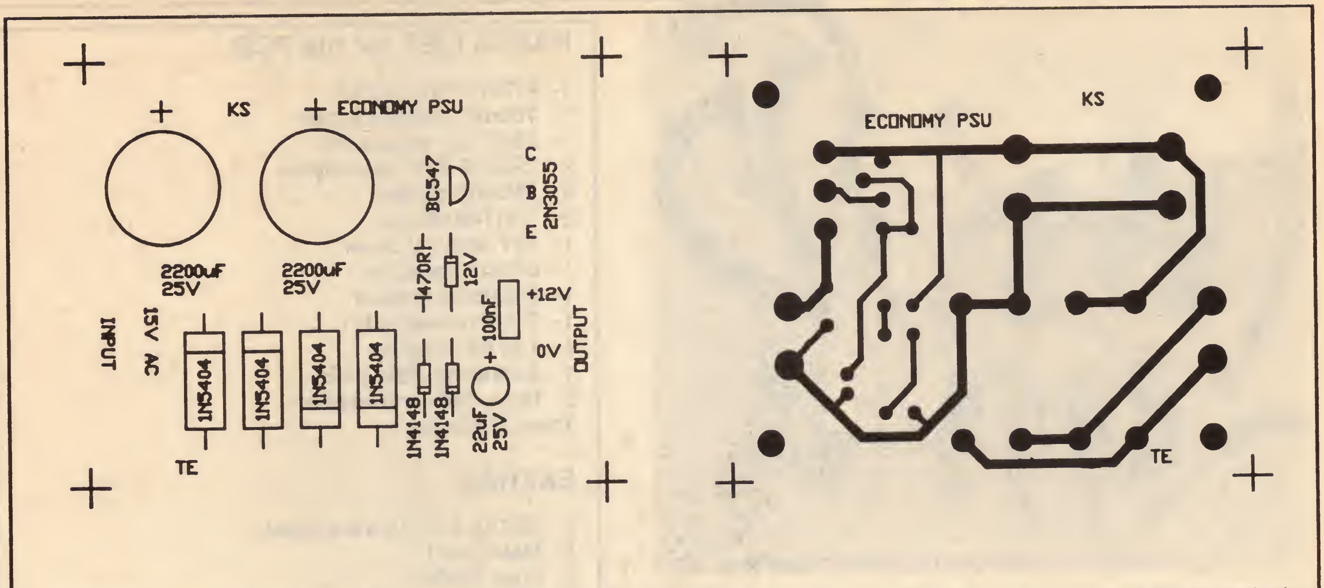
Electronic projects are sensitive to the supply on which they are run. Unlike lamps, they will not run on AC and when the AC is rectified to DC, it must be smoothed to allow the project to work properly.

There are some circuits in this book that include their own simple power supplies. The diesel sound generators are one example. The throttles, too, include their own simple power supplies. However, projects such as the signalling system, the servo drivers, the delay module and the tunnel extender require a regulated power supply to function correctly.

CMOS chips can not be run on more than 18 volts. This is their maximum limit. Any more and they literally explode, so it is wiser to keep the voltage well below this limit. 12 volts is a good choice, as apart from being well below the CMOS limit, this voltage is also suitable for grain of wheat lamps. The power supply must also be able to provide enough current to run several projects, perhaps a complete signalling system and a couple of accessories. I consider a supply capable of delivering 1 to 2 amps to be adequate. Any higher and the design of the supply can become tricky. Better heatsinking is required, and some form of overload protection becomes mandatory. The components required also become expensive and are often not available at hobbiest shops. It is better to use several smaller supplies.



All components except for the transformer, fuse and power transistor fit neatly on the printed circuit board. Once again construction is so simple that beginners should have no trouble assembling it. The 15 volt AC input from the transformer is at the top of the board. The regulated 12 volt output is at the bottom. The connections to the transistor are at the bottom right. Each pad is clearly marked.



The printed circuit artwork and overlay. Refer to the overlay when you are assembling the power supply. Take particular care to get the diodes and electrolytic capacitors the right way around.

As a power supply is not really an interesting project to build and has no potential as a display item, I have kept the circuit as simple and cheap as possible. It still contains all vital circuit sections, but its performance could be considered crude when compared with expensive up-market items. Its output voltage is fixed at roughly 12 volts, but may vary a little with load. It has no overload protection, so it will try to power a short circuit. But should it become damaged, repair will be cheap and easy.

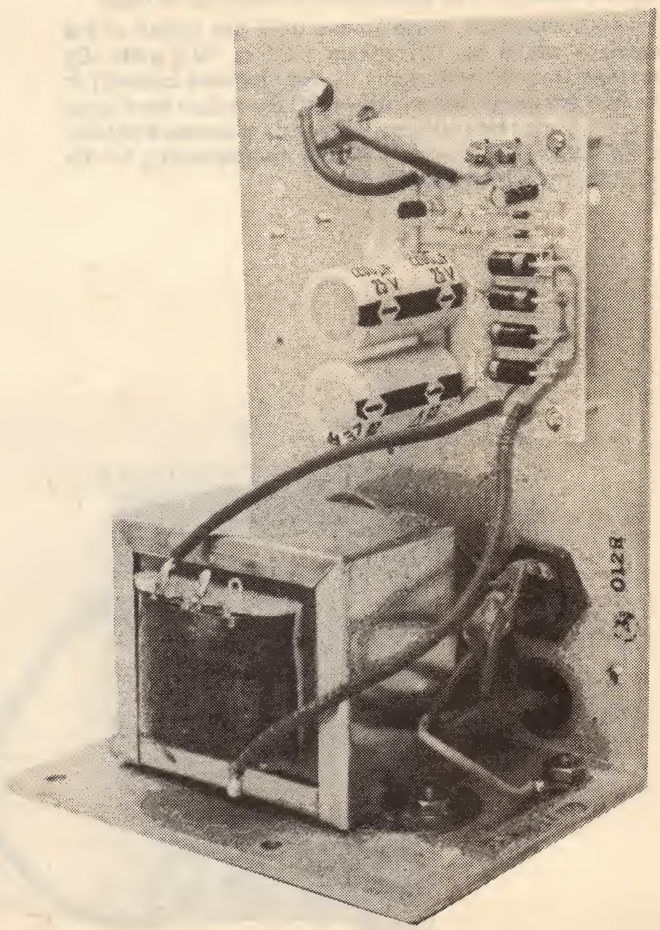
ABOUT THE CIRCUIT

First the mains voltage is reduced to a usable level by the transformer. The 15 volts AC is then rectified by the diode bridge. What we now have is un-smoothed DC, much like the output supplied on some commercial train controllers. This un-smoothed DC is then fed to the electrolytic capacitors. The capacitors charge on the voltage peaks of the un-smoothed DC, then discharge into the load during the gap between the peaks. This smooths the DC. The voltage will still fluctuate a little during the charge/discharge cycle, so further smoothing, or regulating is required.

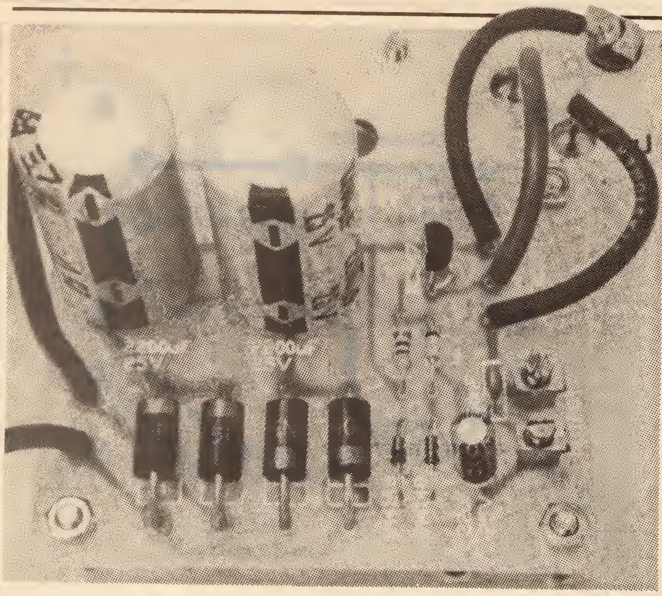
This is where the other components come in. They form a simple zener regulator. The heart of the circuit is the 12 volt zener diode. When a zener diode is reverse biased (fed backwards) it will not conduct until its maximum voltage is reached. At this point the zener will begin to conduct. The zener chosen here begins to conduct at approximately 12 volts.

The 470R and zener form a simple voltage regulator on their own. The 470R resistor provides the zener diode with a current limited supply and the zener will begin to conduct, maintaining 12 volts across itself. The current available for driving a load at this point is very small, only a few milliamps, but is enough to drive a small transistor.

The two transistors, each wired as emitter followers, form a simple darlington current amplifier. Each will try to keep its emitter voltage at 0.6V below that of its base. The first transistor is needed because the gain of the



I built my supply on a piece of aluminium that I had in my junk-box. It provides adequate cooling for the transistor.



second transistor, the power transistor, is not very high. Between them they have a gain of approximately 2000, or higher if a more sensitive power transistor is used. This means that for 1 milliamp present at the base of the first transistor, 2 amps will be available at the emitter of the power transistor, if an appropriate transformer is used.

As each transistor stage looses 0.6V the output of the regulator would be 12V minus 1.2V or 10.8 volts. By inserting two 1N4148 signal diodes (forward biased!) in line with the zener, we are able to lift the output back up to 12 volts. Each 1N4148 has a voltage drop across it of 0.6V, giving a total or 1.2 volts, perfectly compensating for the 1.2 volts lost by the transistors.

PARTS LIST for the PCB

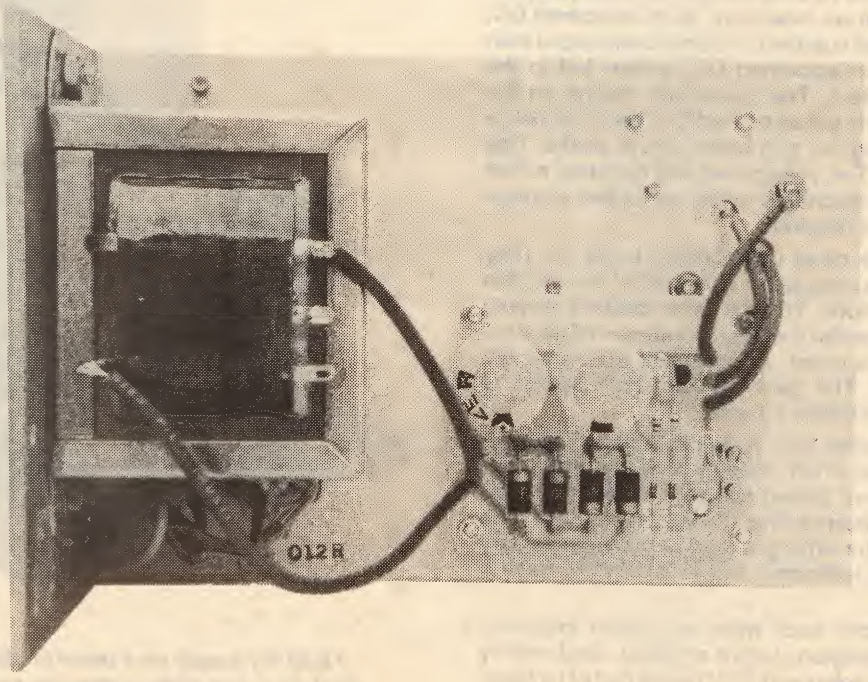
1- 470R 1/4W resistor
1- 100nF monoblock cap
1- 22uF 25v electrolytic.
2- 2200uF 25V electrolytics
4- 1N5404 diodes
2- 1N4148 diodes
1- 12V 400mW zener
1- BC547 transistor
1- 2N3055 transistor
1- TO-3 insulating ki t
1- Tag for collector
1- Economy PSU PCB
2- Nuts, bolts and washers
Thermal grease

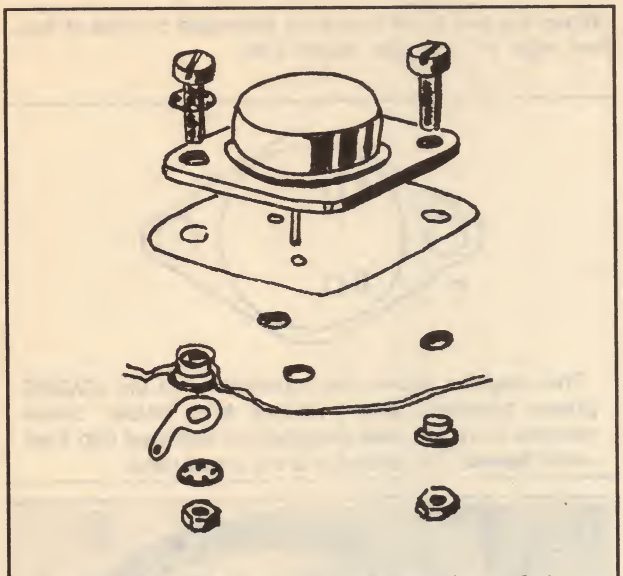
EXTRAS

1- M2156 15V 2A transformer
1- Mains lead
1- Fuse holder
1- 1/2A slow blow fuse
1- Tag for earth
PCB Mounting hardware
Wire
Terminal block
Sheet of aluminium

CONSTRUCTION

I built my supply on a piece of aluminium that had once been part of a power supply for another piece of equipment. It provides adequate heatsinking for the power transistor, as well as a convenient place to mount all of the other components. The transformer chosen for the job is the M2156. It provides taps for 6, 9, 12 and 15 volts AC at 2 amps, and is readily available. Any other 15 volt, 2 amp





This is how to mount the power transistor. Only two small dabs of silicon heatsink grease are required, one on each side of the mica washer. The insulating bushes are pushed into the aluminium from below and the bolts put through them from above. The left hand bolt provides the connection to the transistor's case, which is its collector. Star washers are used to ensure a good connection. After assembly, check between the transistor and aluminium with a multimeter to make sure you don't have a short.

transformer should work as well. Note that due to a quirk of rectification, only 1.4 amps DC will be available at the output of the supply.

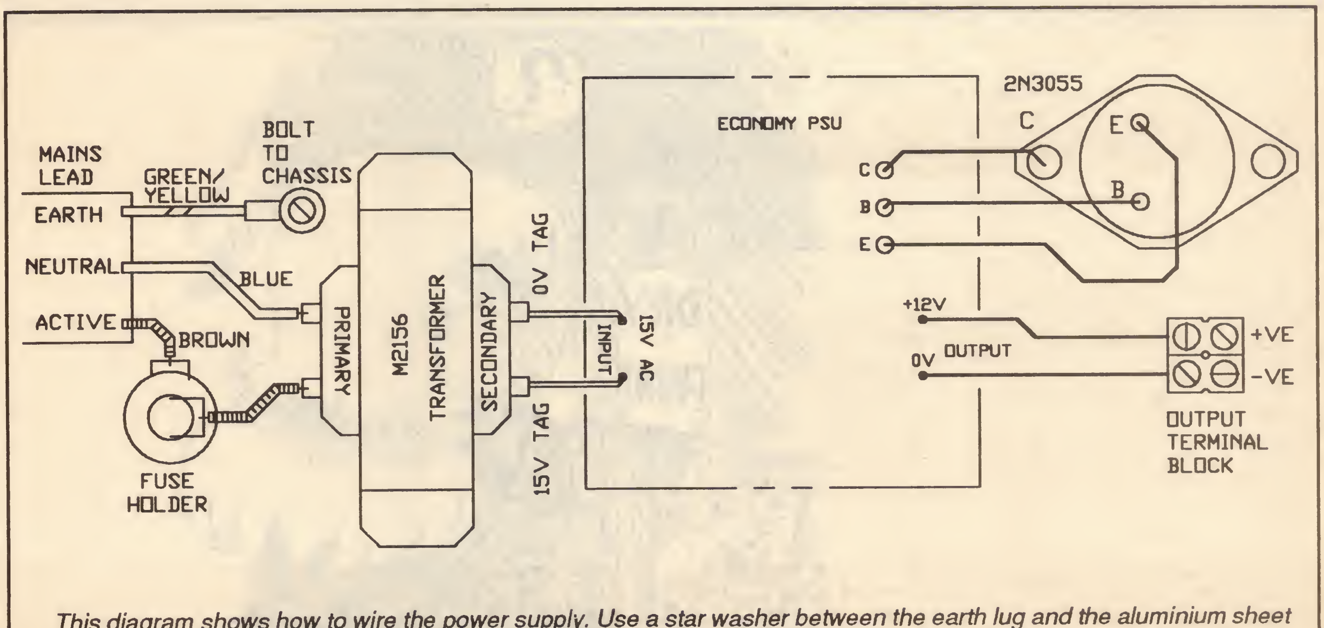
Why? When a transformer's output is rectified and smoothed, the output voltage will be equal to the peak voltage of the transformer, rather that the RMS voltage at which it is rated. The peak voltage is approximately 1.4 times higher than the RMS voltage. (The exact figure used is the square root of 2. However, diode losses will also have an effect, reducing this voltage.) As a transformer can only supply a certain amount of power, 30VA (volt amps) in this case, there must be a corresponding drop in the current available. Therefore, the DC current available is 2 amps divided by the square root of 2, or approximately 1.4 amps. You can try to pull more power out of the supply, but the output voltage will drop and the transformer will overheat and eventually burn out.

Connect the mains lead to it, using a terminal block if the transformer is the type with flying leads. If you wish, you can put a fuse in the active line. Mine uses a 1/2 amp slow blow type. Make sure that you properly anchor the mains lead to prevent it from being torn from the transformer tags or the terminal block. Earth the aluminium sheet. Insulate any bare mains connections with heat-shrink tubing. Mount the transformer so that connections can easily be made to its secondary.

Drill holes for the transistor and printed circuit board in the sheet of aluminium, making sure you don't leave any of the swarf amongst the wiring. Don't position the transistor so that it will be covered by the printed circuit board as this will make wiring difficult. You can use the blank printed circuit board as a drilling template. The mica washer makes a good template for the transistor. Don't drill through it, but rather use it to mark the holes with a pencil.

Next mount the 2N3055 power transistor using an insulating kit. Apply the heatsink grease very sparingly. It is only meant to fill any tiny gaps between the mica washer, transistor and heatsink. Too much of it is detrimental. Don't forget to put a tag under one of the nuts for the connection to the transistor collector. With a multimeter, check to see that you have done the job right. The transistor should be fully isolated from the aluminium. It is also a good idea to check your mains and earth wiring before you power it up.

Next, assemble the printed circuit board, taking care with the polarities of all components except for the resistor and



This diagram shows how to wire the power supply. Use a star washer between the earth lug and the aluminium sheet to make sure that the oxidation layer on the aluminium is punctured. Use another between the lug and the nut. When bolting down the transformer, use star washers under both the bolt heads and nuts, to ensure good earthing. Insulate all mains connections with heat-shrink tubing. Make sure the mains cable is firmly secured with a cable clamp.

100nF capacitor. The 3 amp diodes have rather heavy leads. Do not bend the leads close to the body of the diode, as you may break the diode in the process. It is not a good idea to use pliers to bend the diode leads, but rather gently curve them with your fingers.

With the board sitting where it will be mounted, cut and strip some wires for connection to the power transistor and transformer. You may also like to run the output of the supply to some form of connector or terminal block. Solder the wires to the printed circuit board, then mount it using some short spacers. Make sure that none of your component leads have been left so long that they touch the aluminium. Now solder the wires to the transformer, transistor and your terminal block. Take care with the base and emitter connections to the power transistor. It is easy to swap them if you are not careful.

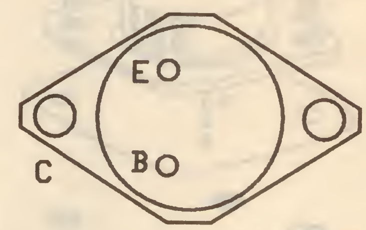
POWERING IT UP

Before you apply mains to the power supply, check and re-check all of your wiring. With mains, you don't get a second chance. Any wire or connection that looks less than perfect must be done again.

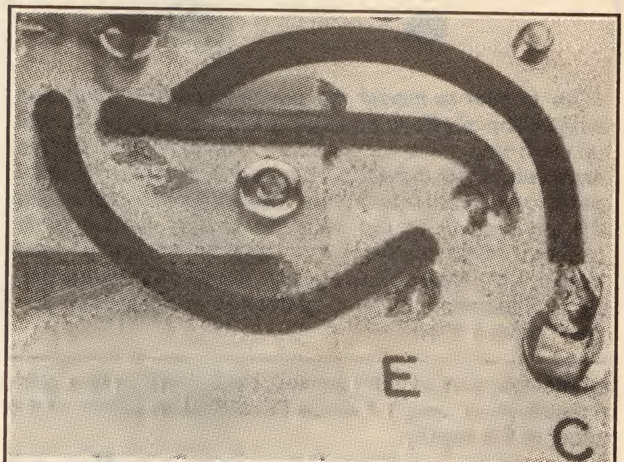
When you are satisfied that all is in order, place it on the bench and plug it in. Switch it on. It should hum quietly. Check the output with a multimeter. It should read somewhere between 12 and 14 volts. If it doesn't, go back and check your wiring and assembly, particularly the orientation of the zener and two 1N4148 diodes. Nothing should be getting hot either.

With the meter still connected, put a load across the output. A 12 volt, 21 watt indicator lamp from a car is ideal. The output voltage should stabilize around 11.5 to 12 volts. If it does, everything is working alright, and you can install the unit on your layout. Install it in a way that nobody can accidently grab a mains connection, even if it is insulated. A shield of aluminium or wood could be fashioned for it.

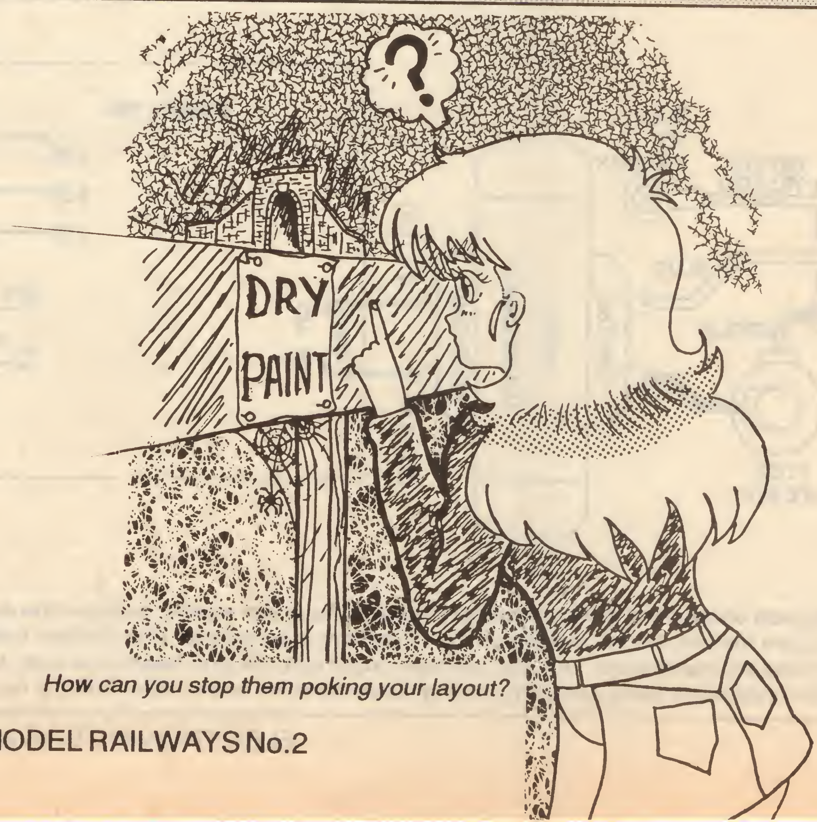
When the unit is not in use for extended periods of time, over night for example, switch it off.



This diagram shows the connections to the 2N3055 power transistor when viewed from below. Some devices have the lead designators stamped into their metal bases. The collector is the metal case.



A close up of the power transistor wiring on the prototype power supply unit.



How can you stop them poking your layout?

SIGNALS

Signals that operate add a high degree of realism to any model railway as well as being something additional for viewers to watch. Unfortunately they are sometimes omitted due to the complexity of controlling them realistically. This article describes a module than can be readily fitted into an existing layout and used to control either two-aspect or three-aspect signalling systems. It can even provide a simple form of automatic train control by deadening blocks to prevent trains from running into each other.

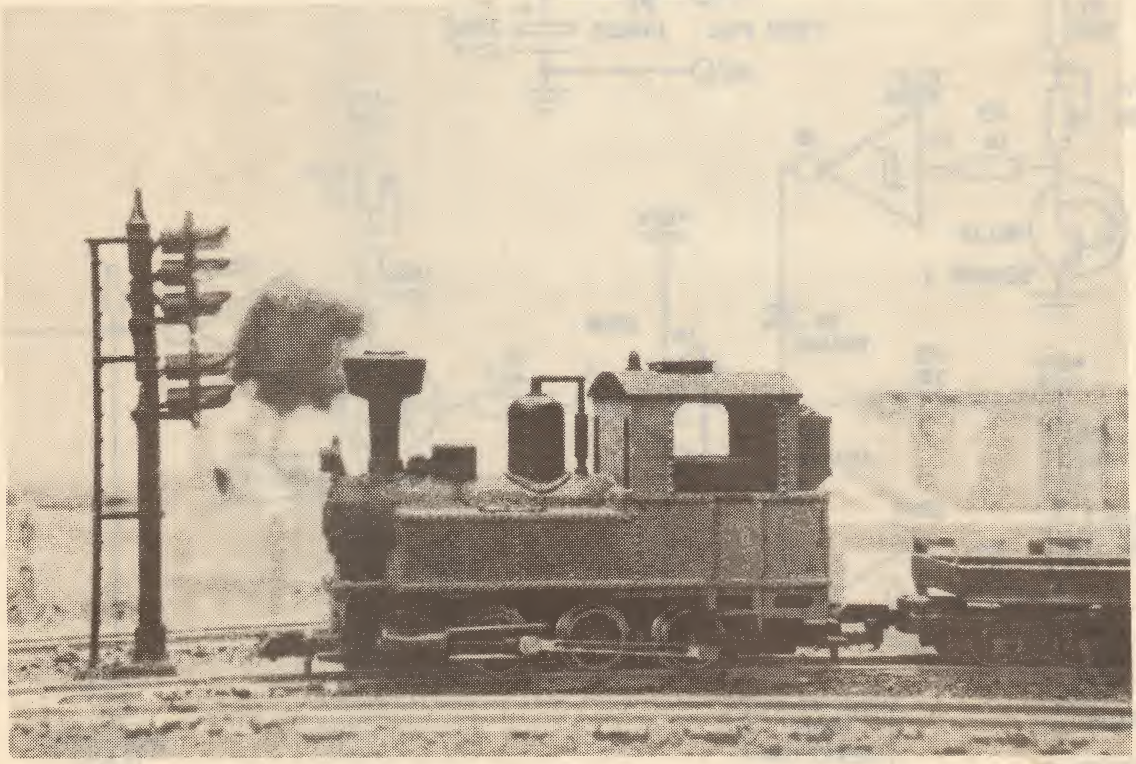
On real railways, signaling systems are varied and complex depending on who designed them and where they are, but their primary purpose is always the same; to stop trains colliding with each other. On model railways their function is a little different. Sure, they can be used to stop trains colliding, but should this unfortunate event occur, the damage will be minimal, and there will be no loss of life (assuming you don't strangle the other @#$% driver for wrecking your brass loco).

The second difference between real signalling systems and those on a model railway is the signal-man or lack there of. Most model railways are operated either solo or on a one man per train basis, leaving no one to look after the signals. It is therefore fairly important that the signals be able to look after themselves. As I see it, the primary function of signals on model railways is to look the part, just like other items of scenery.

Most modellers will not be able to achieve an exact miniature of a real signalling system, due to the time and effort involved. The commercial signals that are available in most model shops are often not very accurate and being modelled after a type of signal used in another country they are not really appropriate. Unless the individual wishes to make his own signals, he will have to settle for something that looks similar enough to fit the part. So with this in mind, I have developed a simple system using modules that can be used either as stand alone units or connected together, rather than attempting to exactly replicate a real system. They work with single direction traffic only. Two systems would be needed if they are to be used on a stretch of track that sees traffic in two directions. The system for the opposite direction would have to be switched off to stop it interfering with the one in use. My model railway has a preferred direction of travel because of the way the points have been laid out, so I have signals facing in only this direction.

I should point out here that for a three aspect signalling system, at least four modules are required. For a two aspect signalling system, three units are called for, but due to the stand alone nature of this circuit when used as a two aspect system, it is possible to use only one module.

The modules will drive either the bulbs used in commercial signals or LEDs. While I'm on the subject of LEDs and lamps, I feel it is a good idea to replace the grain of wheat



A simple set of signals will add action and color to any layout.

lamps in the signals with 3mm LEDs for several reasons. LEDs last a lot longer than lamps. In fact, under normal operating conditions, a LED should never burn out. The more common opaque LEDs give a much more even light than a lamp, and unlike lamps, there is no colored paint to chip off. LEDs draw about a quarter of the current, making less demands on the power supply. LEDs are shorter than lamps, and have a lens that looks the part. The final point of the argument is price. Last time I saw the price of a lamp, I couldn't believe it. They were about ten times the price of a LED!

ABOUT THE CIRCUIT

The circuit consists of four basic parts. The first section is the train detector or sensor, which is mounted under the track between the rails. The second is the adjustable delay that controls the length of time on which the signal remains red. The third section of the circuit is the gate array that determines which light should be on, depending on the status of both the current and next blocks. The final section of the circuit drives the lamps and relay.

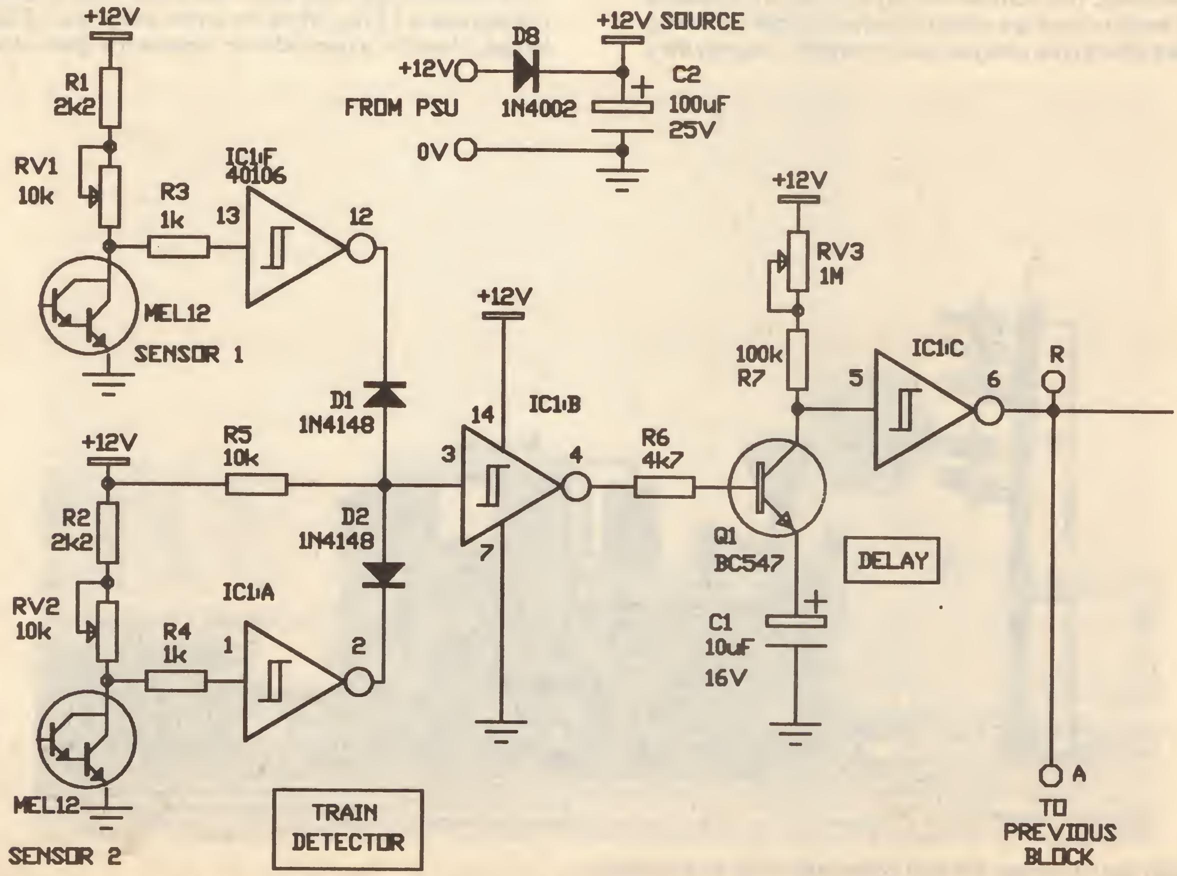
The first section to look at is the delay. It is the delay that makes these signals so easy to use. My original design used flip-flops to remember whether a train was in a block (section of track between signals) or not. There was no way that a train could creep into a block unless the train in front had reset it by moving into the block after it. This was fine, except for a couple of problems. All blocks had to be manually reset on occasion. A shadow passing over the sensor of an empty block was enough to lock the system. It was also very difficult to deal with trains that entered or left the main line. By replacing the flip-flop with a delay, you achieve a very similar result without the above problems.

A train passing over a sensor will set the signal to red, and deaden the block behind it. The delay will be long enough for the train to reach the following block before the red period is over. Even if the train doesn't quite get out of the block in time, and the following train starts moving, it will not be long before the first train reaches the next signal and deadens the block behind it, once again maintaining a minimum distance of one block between the trains.

The only time there will be problems is if the first train comes off the track. The delay will eventually end and allow the following train to enter the same block, resulting in a collision if you don't stop it manually. Unless you are a speed maniac, or just love expresses, this should not worry you.

Each signal module has two optical sensors, one or both of which may be used. The first sensor is placed under the track, one locomotive length into the block (so the train doesn't stop itself!) The second may be placed further along if the block is exceptionally long. If you have two lines coming to a junction, a sensor can be placed in each line and the whole junction made one block, ensuring that only one train can approach the set of points or crossing at a time. If you do not require the second sensor, place a link on the PCB where the second sensor would normally be connected. Failure to do this will result in the unit permanently staying red.

The sensors use a MEL12 darlington photo-transistor as the active element. Light falling on the junction of the first transistor in the darlington pair has the same effect as



The circuit diagram of the signal module.

applying a voltage to the base of the device. It turns the transistor on. The degree of saturation, or how hard the transistor pair is turned on, depends on the intensity of the light.

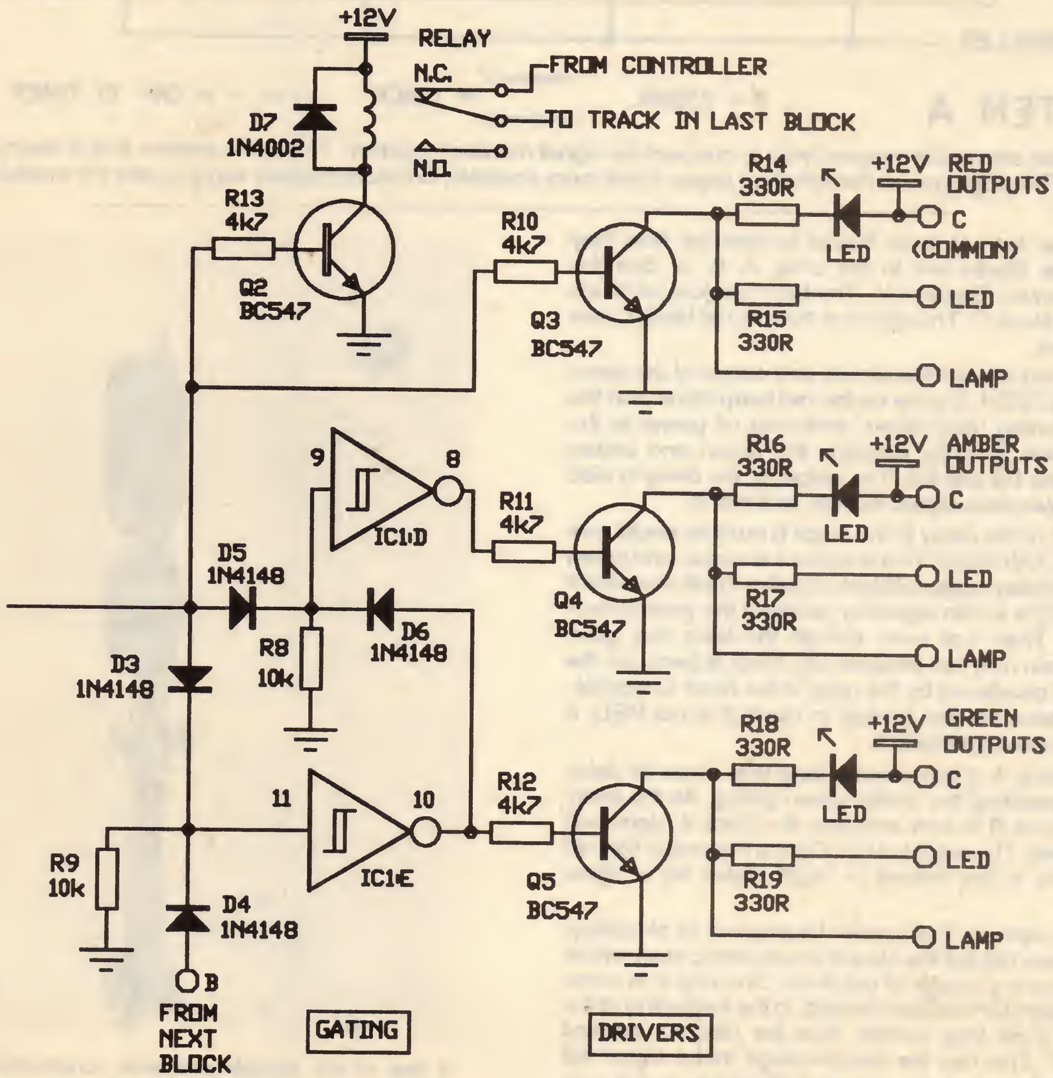
Therefore when light is falling on SENSOR 1, it will hold the input of the schmitt inverter IC1:F (pin 13) LOW via R3. When a train casts a shadow over the MEL12, the transistor will not be turned on as hard, allowing its collector to be pulled up by R1 and RV1. When RV1 has been adjusted correctly, the voltage at this point will rise over the input threshold of the schmitt inverter IC1:F (about 2/3 of the voltage on which the chip is being run, in this case 8 volts) and its output will go LOW (to 0 volts).

I should also mention here that these sensor circuits behave quite differently under various light conditions. They are very sensitive under fluorescent lights, but under incandescent lamps, they are harder to trip. If you find you have problems, you may need to change R1 and R2. Reduce them if you can't make the signals go red, or increase them if the signals won't return to amber or green. When you are making the adjustments, the delay can be disabled by leaving C1 off the board or shortened by clipping a 1k resistor between the 12 volt rail and the collector of Q1.

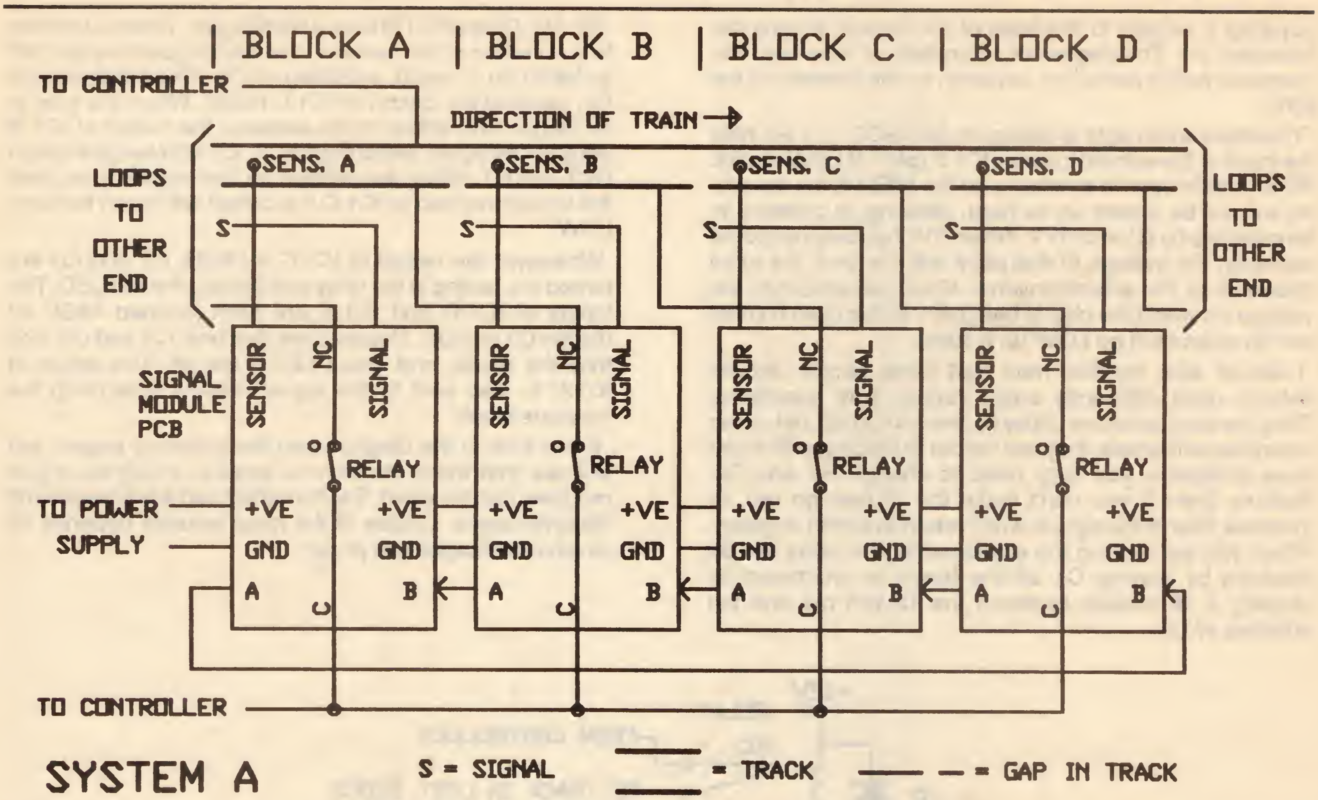
D1, D2, R5 and IC1:B form a NAND gate. When a shadow falls on either of the sensors, the NAND gate's output will go HIGH (to 12 volts), switching on Q1. This will discharge C1, sending the output of IC1:C HIGH. When the train is no longer over either of the sensors, the output of IC1:B will go LOW again, switching off Q1. C1 will charge through RV3 and R7. When the voltage on the capacitor reaches the input threshold of IC1:C the output will revert to being LOW.

Whenever the output of IC1:C is HIGH, Q2 and Q3 are turned on, pulling in the relay and lighting the red LED. The inputs of IC1:D and IC1:E are both jammed HIGH by diodes D3 and D5. This ensures that both Q4 and Q5, and thus the amber and green LEDs, are off. The output of IC1:C is also sent to the signal module controlling the previous block.

If you look at the diagrams on the following pages, you will see that there are several ways in which the signal modules can be wired. Each method had advantages and disadvantages. Choice of the most suitable depends on which advantages you prefer.



The circuit consists of four major blocks: Detectors, Delay, Gating and Drivers. Each is explained in the text.



This diagram shows the simplest way to connect the signal modules together. This is the system that is described in detail in the text. The diagrams on the following pages show more complex, but more realistic ways to wire the modules.

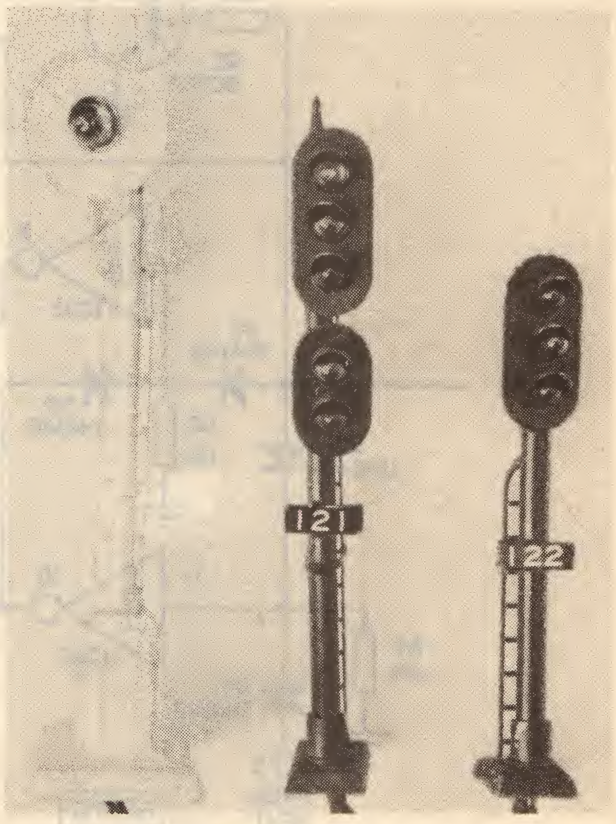
We will now look at three blocks to describe how they interact. The blocks are in the order A, B, C. See the diagram marked "System A". The train has just left block B, entering block C. The signal at the start of block C has just gone red.

The train had tripped the sensor and output of the delay in block C is HIGH. It turns on the red lamp driver and the block deadening relay driver, switching off power to the track in block B, while jamming the green and amber drivers off via D3 and D5. The output of the delay is also sent to the previous signal module, in block B.

The output of the delay in the block B module would now have gone LOW again. This enables the amber and green gating. The delay output of block C (still red) will now select the amber light at this signal by jamming the green driver off via D4. Note that even though the lamp has gone amber, a train may not proceed into block B because the block is still deadened by the relay in the block C module. However, because the module in block B is not RED, a train may move into block A.

Back at block A, it has been a long time since its delay went low, enabling the amber/green gating. As the delay output of block B is now also low, the block A signal will display green. The output of IC1:E jams the amber light off via D6. This is the natural or "rest" status for a signal module.

This is the system that I prefer because of its simplicity, but some may not like the idea of a train sitting at an amber light. There are a couple of solutions. One way is to move the actual signals one block ahead, to the beginning of the section of track they control. See the diagram marked "System B". This has the disadvantage that a signal will remain green as a train passes it changing to red only when the train reaches the next signal. I would not recom-



A few of the signals available commercially. The two spare lamps on the five lamp signal may be driven by the station signal project later in this book.

mend moving the sensors one block in the other direction instead of moving the signals, unless the wires to the sensors can still be kept as short as possible. Due to the sensitive nature of the delay, it is possible that electrical noise generated by the trains may cause false triggering if the sensor wires are too long.

The other solution is to put in more isolated sections of track. Instead of each block being one isolated section, it must become two, a short one (about a loco length) just before the signal and a long one which is the rest of the track between the signals. The short section of track is connected to the deadening relay, stopping any loco just before a red light. The other longer sections from all the blocks from are connected together and back to the controller. This means that you have full control over the speed of the trains at any position on the loop except immediately in front of a signal that is red. See the diagram marked "System C".

In set-ups such as these, there is no individual control of the trains if you have more than one on the loop at a time, but it should stop the faster ones from catching up to the slower ones.

If you only ever run one train on your layout at a time, or if you feel you don't require the block deadening function, it may be ignored. The signals will still work as described above. Use the "System F" drawing when wiring the modules.

If you wish to use the signal modules as stand alone units, or to drive two aspect (red/green) signals, it can be easily achieved by leaving out the wires that link the modules. Note that leaving out this wire forces the unit to operate as two aspect. It is not possible to run the circuit as a stand alone three aspect module. When using the block deadening function with two aspect signals, it will be necessary to position the signals one block ahead (System D) or to use the long/short section method described above (System E). Otherwise, you will have trains sitting at a signals while they are green!

PARTS LIST

6- 330R all 1/4 watt
2- 1k
2- 2k2
5- 4k7
3- 10k
1- 100k

2- 10k mini trimpots
1- 1M mini trimpot

1- 10uF 16V electro
1- 100uF 25V electro

6- 1N4148 diodes
2- 1N4002 diodes

1- 40106 Hex Schmitt Inverter

5- BC547 transistors

2- MEL12 photo-transistors

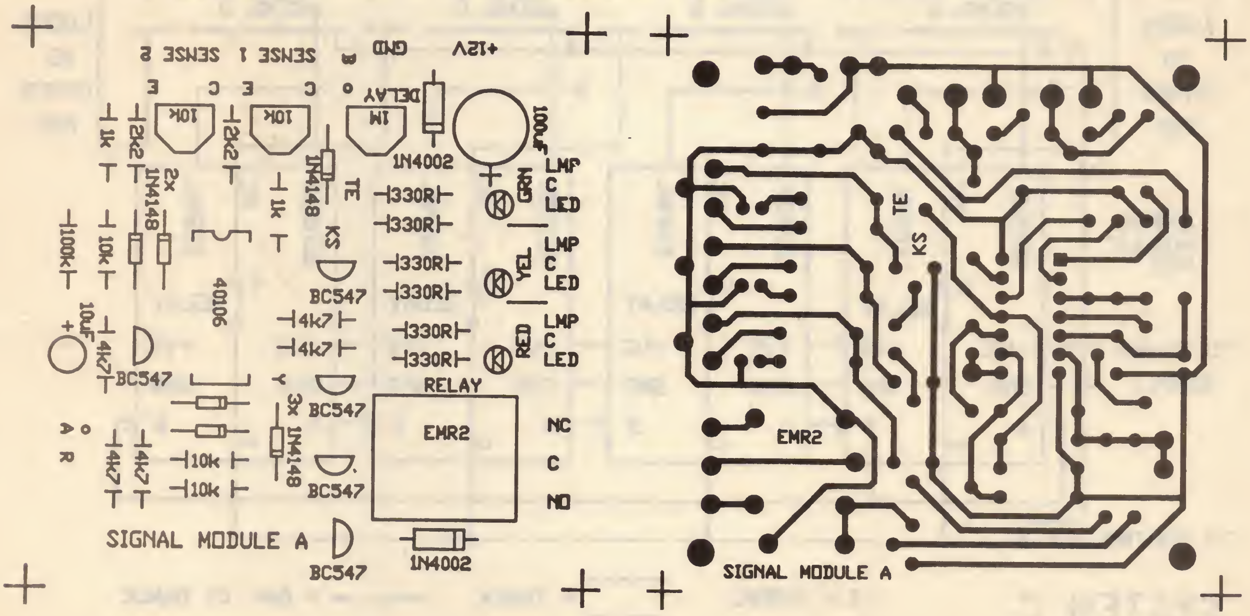
1- Red 3mm LED
1- Orange 3mm LED
1- Green 3mm LED

1- 14 pin IC socket

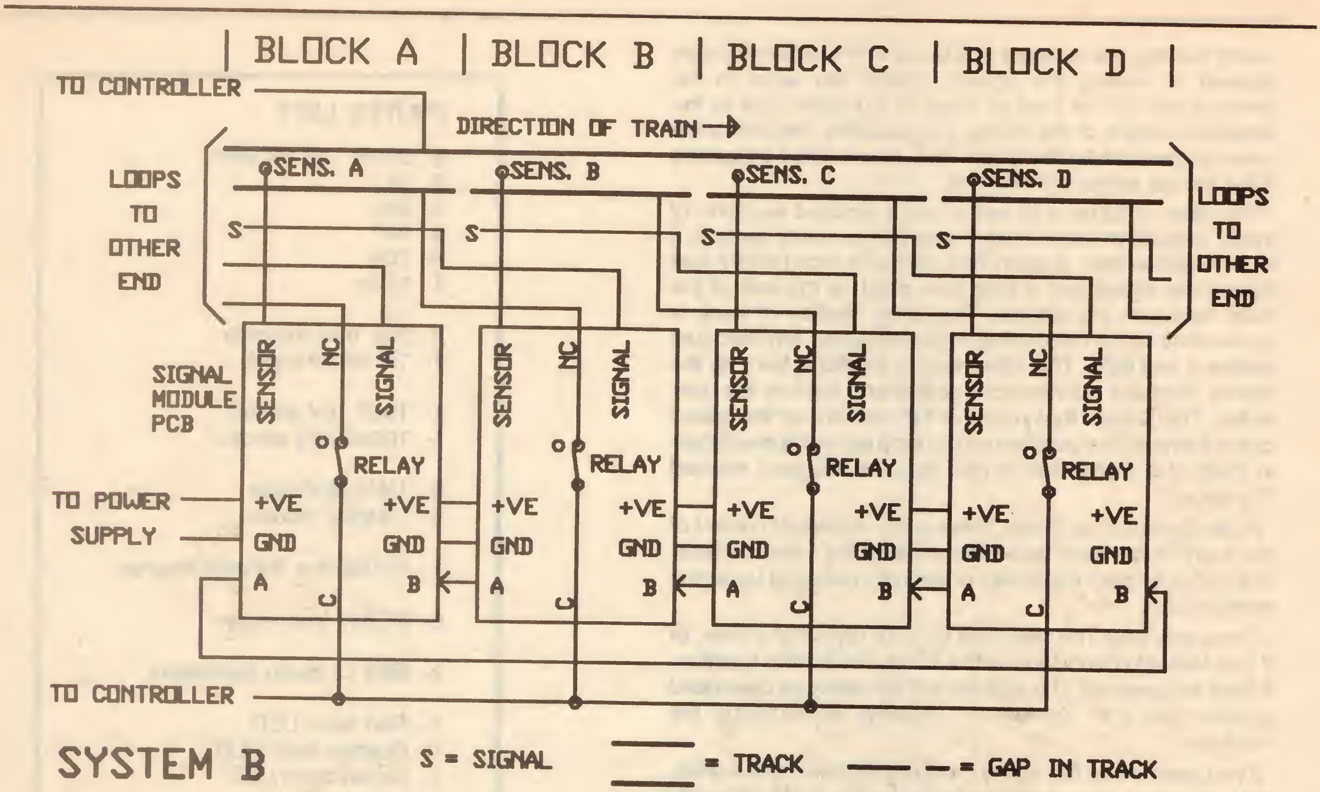
1- **SIGNAL MODULE PCB**

EXTRAS:

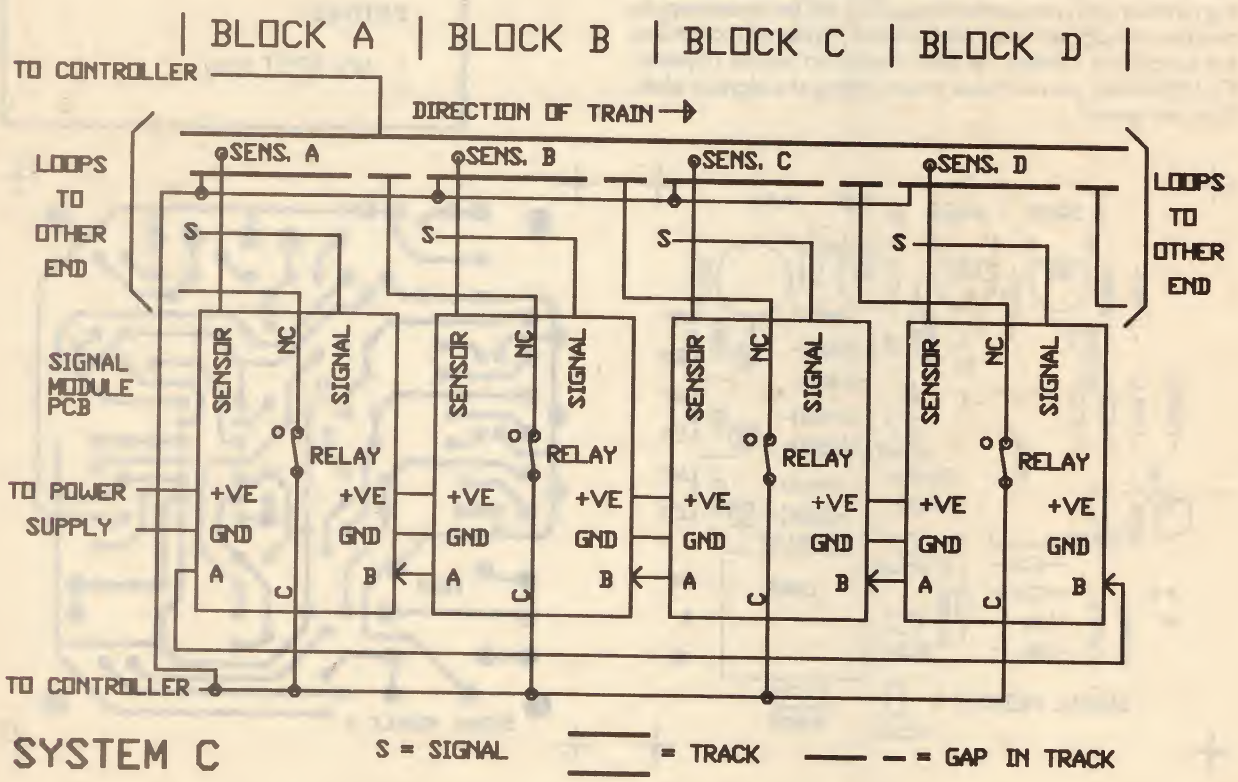
1- 12V SPDT relay



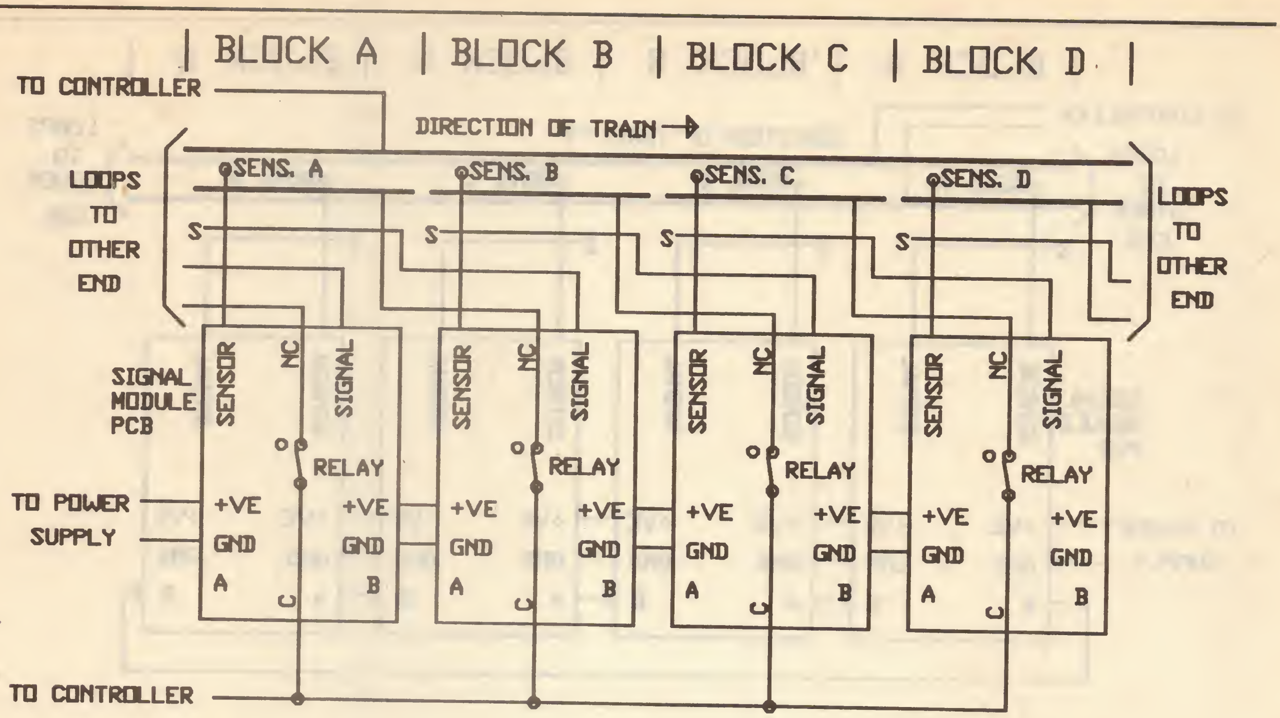
The printed circuit board artwork for the signal module. If you do not require the second sensor, place a link on the PCB where the second sensor would normally be connected. Failure to do so will result in the signal staying red.



System B overcomes the problem of trains stopping at amber lights, but leaves a green light at the beginning of the block containing the train. It is the second easiest way to wire a three aspect system.



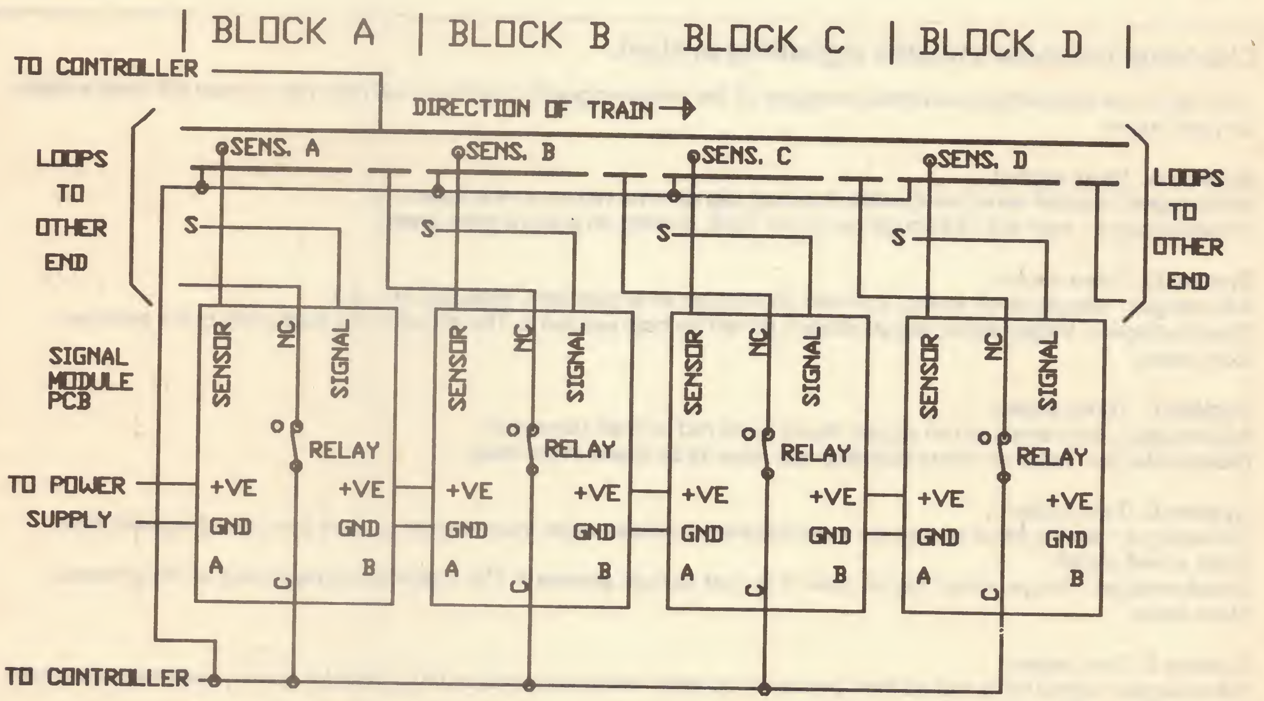
System C requires more track cutting and wiring than the previous two systems, but operates in the most realistic manner.



SYSTEM D

S = SIGNAL ═══ = TRACK ——— — — = GAP IN TRACK

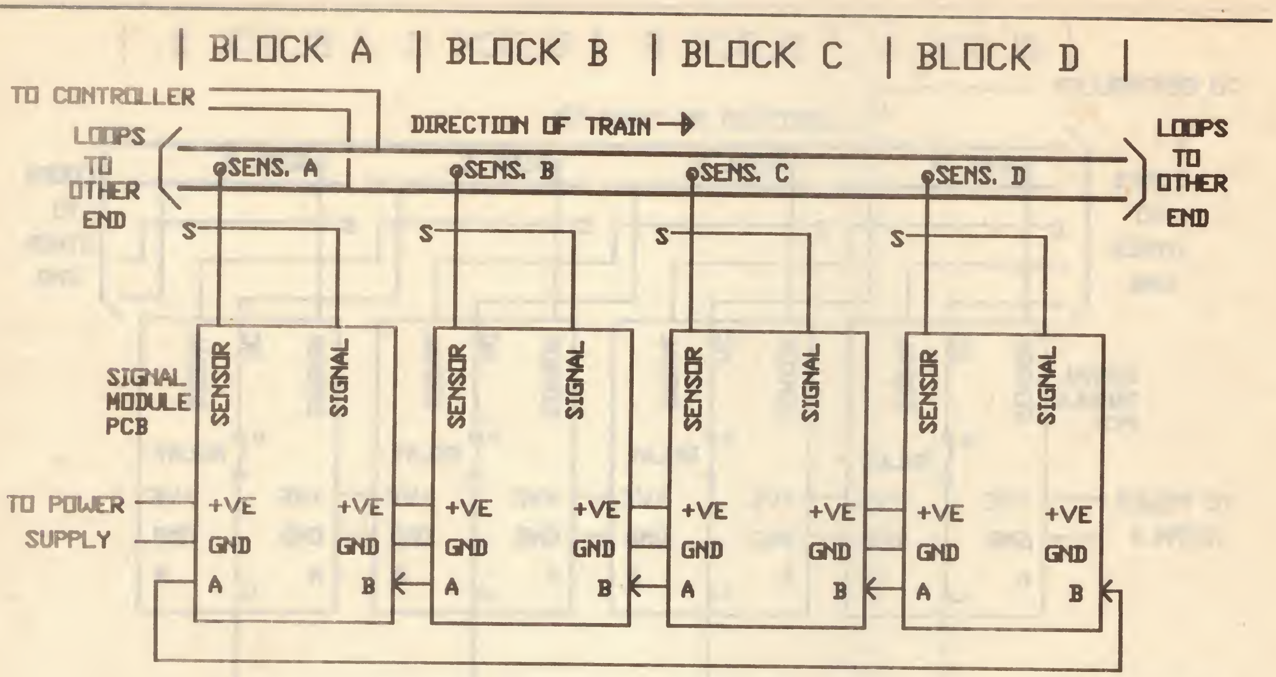
This is the simpler of the ways to wire a two aspect system but it does have a couple of problems. One is that the signal at the beginning of the block containing the train will be displaying green. The other is the length of wire that is required to go between the signals and the printed circuit boards.



SYSTEM E

S = SIGNAL ═══ = TRACK ——— — — = GAP IN TRACK

This diagram shows how to wire the modules for the more realistic of the two aspect systems. Each block is effectively a stand alone module, totally independent of the modules to either side. Like all of the systems, there is no maximum number of modules that you can have in the loop.



SYSTEM F

Of course, if you don't want block control, you can leave out the relays and track wiring. This diagram shows the three aspect system without block control. For a two aspect system, leave out the wires linking the "A" pad on one board to the "B" pad on the next.

Choosing the most suitable signalling system.

This list of the advantages and disadvantages of the various signalling systems will help you choose the most suitable for your layout.

System A. Three aspect.
Advantages:- shorter wires; simple block wiring; signal turns red as a train passes it.
Disadvantages:- train will sit through an amber light, moving off when it goes green.

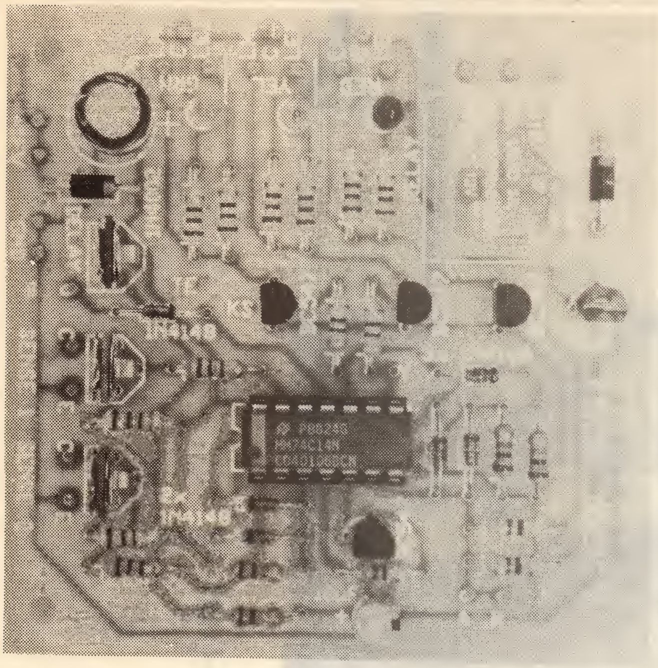
System B. Three aspect.
Advantages:- simple block wiring; train will go through an amber light, stopping at a red.
Disadvantages:- longer wires; signal doesn't go red as train passes it. The signal at the beginning of the previous block does.

System C. Three aspect.
Advantages:- train stops at red signal; signal turns red as train passes it.
Disadvantages:- twice as many isolating cuts have to be made in the track.

System D. Two aspect.
Advantages:- simple block wiring; no wires between modules other than for power; uses two aspect signals; train stops at red signal.
Disadvantages:- longer wires; signal doesn't go red as train passes it. The signal at the beginning of the previous block does.

System E. Two aspect.
Advantages:- signal turns red as train passes it; no wires between modules other than for power; uses two aspect signals; train stops at red signal.
Disadvantages:- twice as many isolating cuts have to be made to the track; track wiring is more complex.

System F. Two or three aspect.
Advantages:- The simplest to wire. Lights turn red as train passes.
Disadvantages:- No block deadening function.



BUILDING THE MODULES

After deciding which system is most suitable for your needs, you can commence building the modules. If you don't require the amber lamp, its driver may be omitted, but I think it is a good idea to install it anyway, just in case you decide to upgrade. The couple of components you would save aren't worth much.

If you don't require the block deadening function, the relays can be left out. As these are worth a couple of dollars each, the savings soon build up.

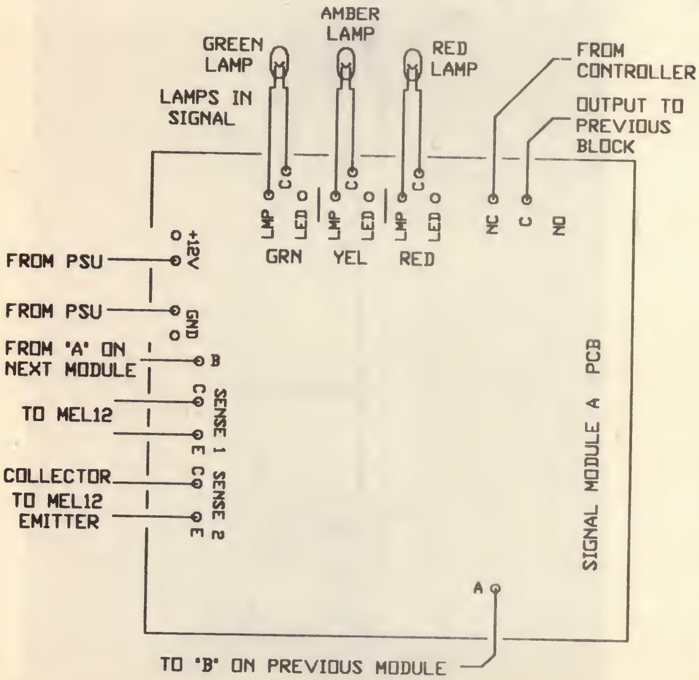
Assembly is facilitated by the use of printed circuit boards. Start with the lower components first, working your way up to the tallest. Don't mount the MEL12 photo-transistors on the board. They should be connected to short flying leads, so they can be pushed up through a hole between the tracks. If the leads become too long, it may be necessary to use shielded wire to stop induced noise from triggering the module. If noise problems persist, try connecting 100nF capacitors from the 0 volt rail of the printed circuit board to pin 1 and pin 13 of IC1.

The two 10k trimpots are for adjusting the sensitivity of the sensors. Each one is mounted next to the input of the sensor it affects. The third trimpot is for adjusting the length of the delay, to allow for different block lengths.

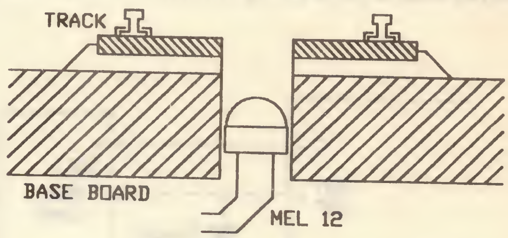
Each driver has three outputs. One is for a grain of wheat lamp, one is for a LED. The third is the LED on the PCB itself. These PCB mounted LEDs make trouble shooting much easier. If you are working on the boards under the layout, it saves you having to crawl out every time you need to look at a signal. If you wish, they could be mounted remotely on a mimic panel near your throttle to let you know the condition of the signals around your layout.

As I mentioned before, I think it is a good idea to use LEDs instead of lamps for the signals themselves. If you do this, make sure that you common the anodes of the LEDs (the long leads) and run the cathodes back to the driver outputs. I managed to wire one of my signals as common cathode, much to my dismay. To make it worse the @#$% thing is the only signal I can't remove to modify, as it is halfway down the underground loop on my N gauge set. The other wiring error to avoid is connecting a signal made with LEDs to the lamp output of the module. As there are no resistors in line with these outputs, the LEDs would be destroyed instantly.

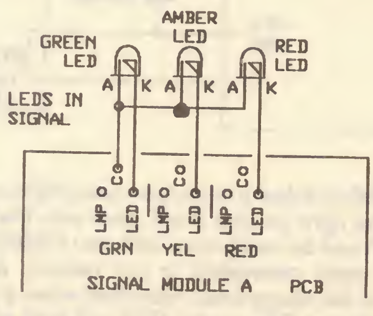
It is also possible to use tri-colored LEDs for both two and three aspect signals if you wish to model searchlight type signals. The Searchlight Adapter presented in Electronics for Model Railways volume #1 is ideal for adapting the



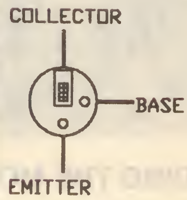
This diagram shows all PCB wiring for the Signal Module. Some wires will not be required on the simpler systems.



Mount the MEL12 in a hole drilled between the rails. Its exact position will depend on the light source you are using.



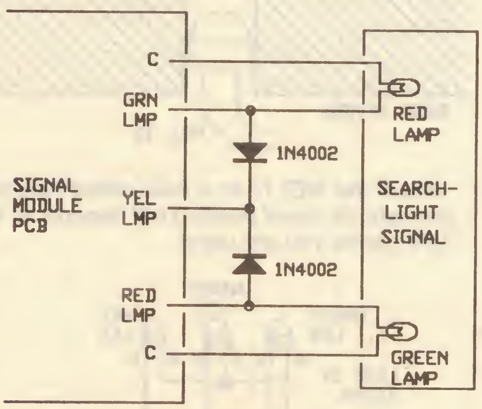
If you wish to use LEDs instead of lamps, wire them to the PCB like this.



The MEL12 viewed from above. Refer to this diagram when you are wiring the MEL12 photo-transistor.

three aspect output of the signal modules to the binary signal required by the tri-colored LEDs. Note that the tri-colored LEDs to use are the ones with three wires. A wire for the common cathode and one each for the red and green LEDs that the tri-colored LED houses. The tri-colored LEDs that have only two wires are a lot harder to drive, requiring a pulse train to generate the yellow color. They are not compatible with the system described.

One final note about the modules: when first switched on, C1 will be discharged. This means that all signals will start on red, changing to green as their delays time out. It will give you time to make sure your points are all correctly set.

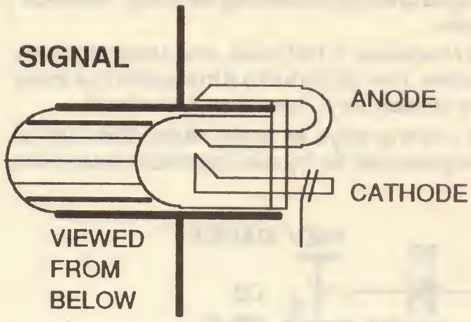


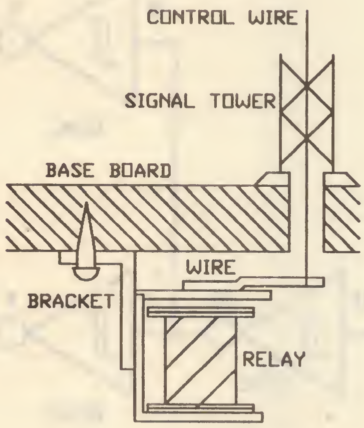
If you wish to adapt a lamp type searchlight signal, like the one to the right so that it will work with the three aspect system, It can be easily done with two 1N4002 diodes. The "yellow" color generated is not perfect, but is distinct enough to be recognised. Note that when you have done this, all three LEDs on the PCB will light when amber is selected.

These photos show both LED and lamp type signals. The LED signal looks a lot neater and more to scale than the signals using lamps. The LEDs also light a lot more evenly, making the signals easier to see.

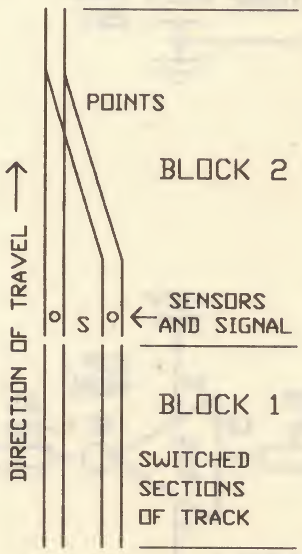
Wire wrap wire of different colors was used to connect to the LEDs. The anodes of the LEDs are carefully bent back so they can be soldered to the body of the signal. This holds the LEDs in place and provides the common anode connection.

The photographs and drawing shows how I have done this. The back of the LEDs will need to be painted black to stop the light from shining out the back of the signal.





*If you wish to experiment with semaphore signals, an old relay can be modified to control the signal. It must be a 12V relay, **NOT** a point motor. A stiff wire is soldered to the armature of the relay. The length of the wire will depends on how far the armature moves when it pulls in. The control wire or thread that runs up to the signal arm is connected to this wire. Arrange the signal arm so that the relay lifts it and gravity lowers it. Don't forget to put a 1N4002 diode across the coil of the relay.*



As I mentioned in the text, the Signal Module can be used to stop trains colliding at a set of points or a diamond crossing. Due to the increased number of tracks that must be isolated, an extra relay may be required. The Remote Relay Unit from Electronics For Model Railways No.1 is ideal for this. It can be connected to the pad marked "R" on the Signal Module. The relay will close when the signal goes RED.

TUNNEL STRETCHER & STATION SIGNAL

Do you find your tunnels a bit short? Does the train pop out of the far end moments after the last coach disappears from view? This module will automatically add some time to the train's trip through the tunnel. It can also be used to control signals at stations, making a train wait for a predetermined time before letting it continue.

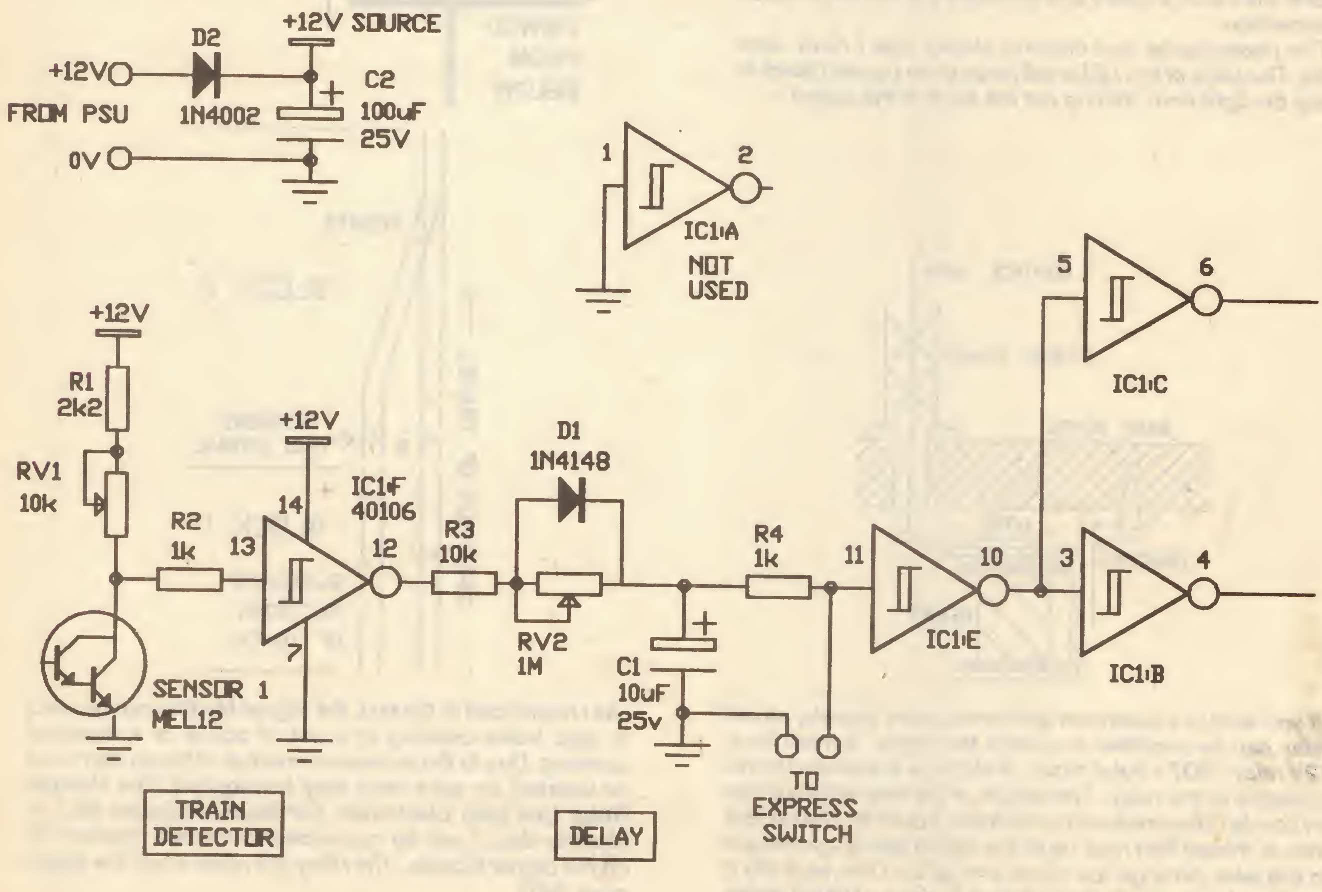
One common problem with model railways is the length of tunnels. Some people will include tunnels just for the sake of it, their tunnels being shorter than their trains! No amount of electronics will make such a train set look any better. Bulldozing is the only solution.

However, if your tunnel is of a reasonable length, you will find this circuit of great use. The train will vanish into the tunnel and wait a predetermined time before emerging again. This delay is great for stretching the scale "distance" between stations.

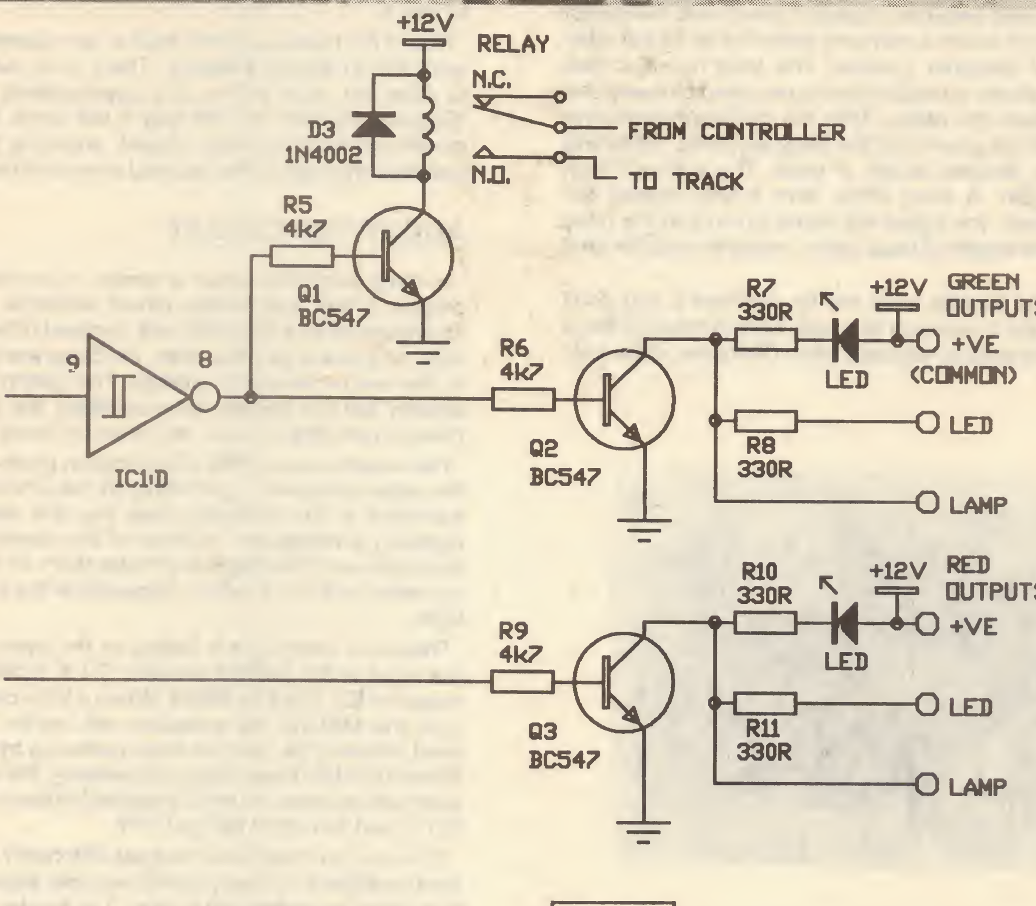
If we consider N scale as 1/160 scale, one scale kilometre is only 6.25 metres. I would be lucky if my layout has more than 12 metres of track on it. Less than two miles!!

On timetable running days at some clubs, this lack of distance is compensated for by running clocks four times as fast. However, spectators would not be likely to appreciate this trick, taking things exactly as they appeared. By putting a delay in my 3 metre long tunnel I can stretch the scale journey out. It helps defeat the "train set" image that short runs generate. Another thing that helps is the physical layout of the tunnel itself. The entrance and exit of my tunnel are only about 10cm apart, each in its own cutting. The track actually loops in the tunnel. With the delay, it looks like a train heads south to a station further down the line, returning later on the north bound line.

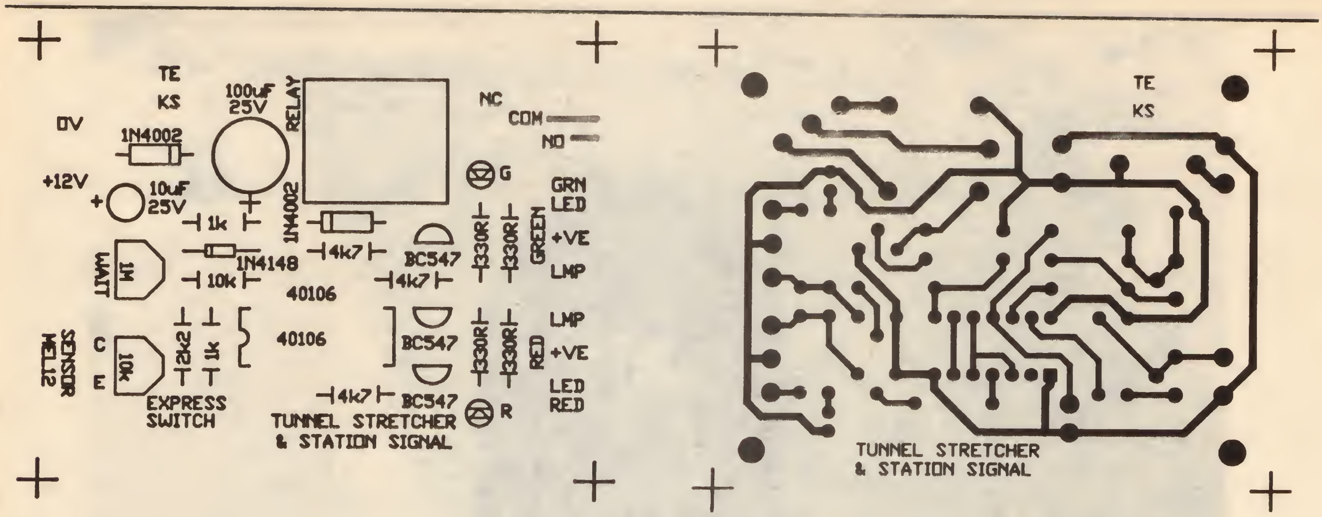
There is also another use to which this handy module can be put. You will notice that it sports LED and lamp drivers so a two aspect signal can be connected to it. If this signal is put at the end of a station platform, along with the sensor and an isolated length of track, it works as a station signal.



The Tunnel Stretcher and Station Signal circuit.



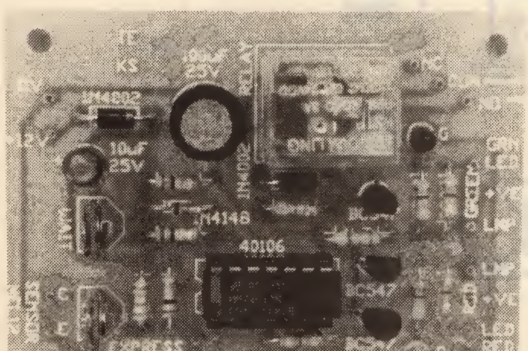
Many of the circuit elements are similar to those used in the Signal Module project. The primary differences are in how the circuit elements are connected together.



The printed circuit artwork for the Tunnel Stretcher and Station Signal. The 10k resistor near the 1M trimpot is the resistor that must be increased if you find the GREEN time of the signal too short. Try 100k or 220k. Remember that this will effect the overall time length too.

The signal will remain on red until a train drives up to it. The train will stop because it has just driven onto the length of isolated track which is currently switched off by the relay in the tunnel stretcher module. The train has also just covered the photo-transistor that is mounted between the rails. This starts the delay. After the predetermined time the signal will go green and the relay will close, switching power to the isolated length of track. The train will then move off again. A short while after it has cleared the photo-transistor, the signal will revert to red and the relay will isolate the length of track again, ready to stop the next train.

Some careful throttle work will be required if you don't want your train to screech to a halt, only to take off like a startled rabbit several seconds later. Of course, if the train is on a tunnel, it won't matter because no one will be able to see it.



All components fit neatly onto the printed circuit board. Again clearances and track thicknesses have been arranged with the beginner in mind.

What if the train is a goods train or an express? You don't want that to stop at a station. There is an override switch to allow for such trains. It is appropriately labelled the "Express Switch" and closing it will force the signal to green and hold the relay closed, ensuring that power is switched through to the isolated stretch of track.

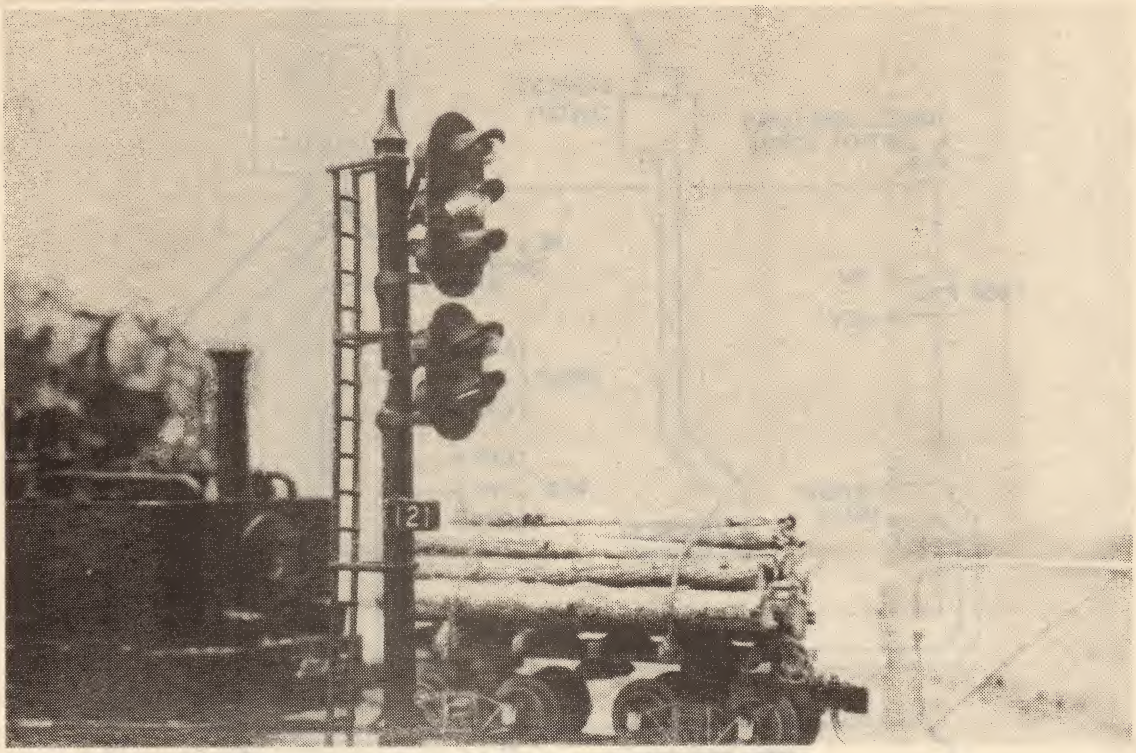
ABOUT THE CIRCUIT

In many ways this circuit is similar to the Signal Module project. It has four similar circuit sections, though their arrangement is a little different. Instead of two track sensors, only one is needed. Also, the delay works backwards to the one in the signal module. The gating is somewhat simpler but the drivers are essentially the same though there is one less of them, as no amber lamp is needed.

The sensor uses a MEL12 darlington photo-transistor as the active element. Light falling on the junction of the first transistor in the darlington pair has the same effect as applying a voltage to the base of the device. It turns the transistor on. The degree of saturation, or how hard the transistor pair is turned on, depends on the intensity of the light.

Therefore when light is falling on the sensor, it will hold the input of the schmitt inverter IC1:F LOW via R2. The output of IC1:F will be HIGH. When a train casts a shadow over the MEL12, the transistor will not be turned on as hard, allowing its collector to be pulled up by R1 and RV1. When RV1 has been adjusted correctly, the voltage at this point will rise over the input threshold of the schmitt inverter IC1:F and its output will go LOW.

This sensor circuit behaves quite differently under various light conditions. It is very sensitive under fluorescent lights, but under incandescent lamps, it is harder to trip. If you find you have problems, you may need to change R1 and R2. Reduce them if you can't make the signals go GREEN, or increase them if the signals won't return to RED. When you are making the adjustments, the delay can be disabled



The five lamp signal is ideal for combining the Station Signal with the three-aspect Signal Module. The circuits are independent of each other, sharing only power connections and the signal itself. The signal still uses lamps for photographic reasons.

by leaving C1 off the board or shortened by winding the 1M trimpot fully clockwise.

In some dark areas on your layout, you may find that you need to mount a street light so that some light falls on the sensor. Experimenters may also like to try hiding infra red LEDs in overhead gantries or in tunnels. Their light is not visible to the human eye.

When the output of IC1:F is high, C1 will be held charged via R3 and D1. The voltage will be above the upper threshold of IC1:E, resulting in a LOW at the output (pin 10) of IC1:E. The signal is then inverted again by IC1:B, resulting in a HIGH being fed via R9 to Q3. This turns on the RED LED. From this we can see that an even number of inverters in series will give a non inverted or "buffered" output. An odd number of inverters in series will give an inverted output. There are three inverters between C1 and the GREEN LED and relay drivers, resulting in an inversion with respect to C1, so both of these will be off any time the RED LED is on, and vice versa.

When a train causes a shadow to fall on the sensor, the output of IC1:F goes LOW. C1 will discharge slowly through the 1M trimpot and R3. When the voltage on C1 falls below the lower threshold of IC1:E, the GREEN LED will be switched on and the relay will close, switching power through to the track. This will allow the train to move off.

As soon as light falls on the sensor again, the output of IC1:F will go HIGH again, charging C1 via R3 and D1, sending the signals back to RED and opening the relay, isolating the track. The charging of C1 is a lot faster than its discharging, making the time before power is removed from the track rather short. Depending on the positioning of the sensor and it's light source, you may find that the locomotive does not make it off the isolated section of track before the relay cuts power to it again. If this happens, the locomotive will be stuck unless you hit the express switch. The solution is to increase the time it takes to charge C1. This is done by increasing R3 to 100k or even higher if you find the time still not long enough. Increasing R3 also stretches the length of time before the signal will turn GREEN when a train arrives.

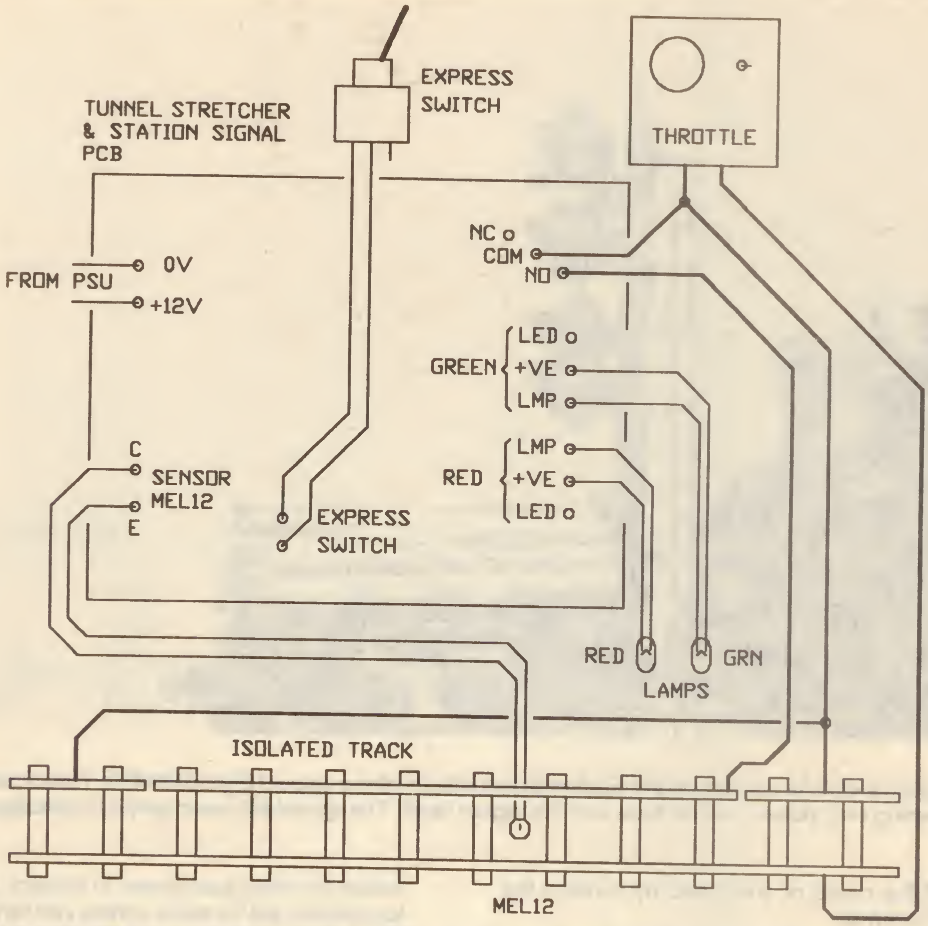
With the component values given, the maximum delay is about 20 seconds. Increasing C1 to 22uF will double this time.

The Express Switch works by shorting the input of IC1:E to the 0V rail. This forces the signal to GREEN and closes the relay. R4 is there to prevent C1 from damaging the switch contacts by rapidly discharging through them.

D2 provides protection for the module, should you accidently connect it to a supply backwards. C2 provides decoupling for the board. In other words, it helps smooth fluctuations on the module's 12 volt rail caused by parts of the circuit switching on or off.

And while I'm discussing the 12 volt rail, I'll explain the convention I use to show it on circuit diagrams. The +12V symbol labelled "SOURCE" is the common point for all the parts of the circuit that require 12 volts. All other +12V symbols are connected to it. It is really a system much like that used for the 0V or GROUND rail.

In some circuits you will notice that the GROUND symbol has been replaced by a small triangle. This symbol represents a COMMON rail. It is often used where the circuit's 0V rail is relative or in other words, not actually at 0V but offset by another voltage. Such a circuit is the onboard diesel sound generator presented later in this book. Due to a bridge rectifier, it's "0V" rail is not at 0V if compared with the 0V rail of the train tracks.



How to wire the Tunnel Stretcher and Station Signal module to the throttle and track. Refer to the diagram below if your signal uses LEDS instead of lamps.

BUILDING THE MODULE

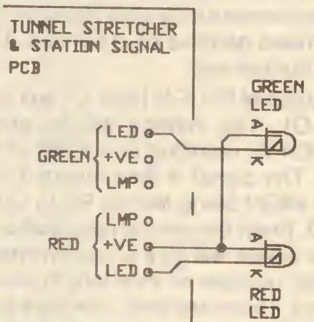
The Tunnel Stretcher and Station Signal project is constructed on a printed circuit board measuring 58mm by 73mm. There is ample space between components, and the track and pad sizes are big enough to make the beginner's job easier.

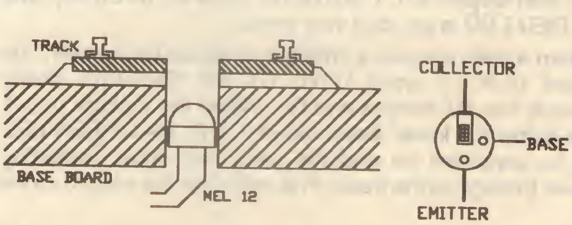
Start with the lower components first, working your way up to the tallest. Don't mount the MEL12 photo-transistor on the board. It should be connected to short flying leads, and pushed up through a hole between the tracks.

Use a socket for the IC. The IC should be the last thing you install before powering the board. Take care with orientation. If, when you first power the board, you find nothing happens, check to make sure you have remembered to put the chip in the socket. It may sound ridiculous, but it is a very easy mistake to make.

The 10k trimpot is for adjusting the sensitivity of the sensor. It is mounted next to the pads to which the sensor is connected. The 1M trimpot is for adjusting the length of the delay.

Each driver has three outputs. One is for a grain of wheat lamp, one is for a LED. The third is the LED on the PCB itself. These PCB mounted LEDs make trouble shooting much easier. If you are working on the boards under the layout, it saves you having to crawl out every time you need to look at the signal. If the unit is being used in a



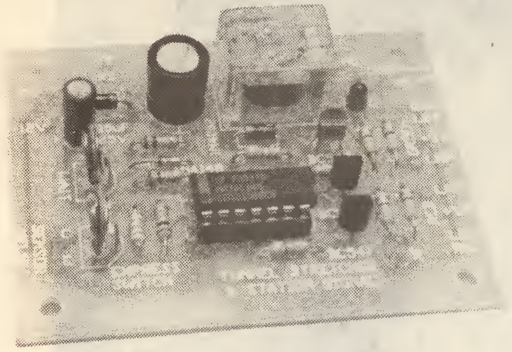


The MEL12 photo-transistor pinout, and how to mount it below the track on your layout. On larger scales, the hole can be drilled between sleepers. With N scale track one sleeper may need to be removed. If you are careful with the positioning of the hole, you may be able to get the active part of the MEL12 lined up with the gap between the sleepers. Be careful that stray ballast does not fall down the hole and cover the MEL12.

tunnel, it is more than likely that there won't be a signal to look at!

Again it is a good idea to use LEDs instead of lamps for the signals themselves. If you do this, make sure that you common the anodes of the LEDs (the long leads) and run the cathodes back to the driver outputs. A wiring error to avoid is connecting a signal made with LEDs to the lamp (LMP) output of the module. As there are no resistors in line with these outputs, the LEDs would be destroyed instantly. Refer to the diagrams and photographs in the Signals project.

A tri-colored LED can be easily used with this module. The common cathode wire is connected to the zero volt rail of the PCB. The red and green LEDs that the tri-colored LED houses are connected via 1k resistors to pins 4 and 8 of the IC. The red LED goes to pin 4, the green one to pin 8.



PARTS LIST

4- 330R
2- 1k
1- 2k2
3- 4k7
1- 10k
1- 100k See Text
1- 10k mini trimpot
1- 1M mini trimpot

1- 10uF 25V electro
1- 100uF 25v electro

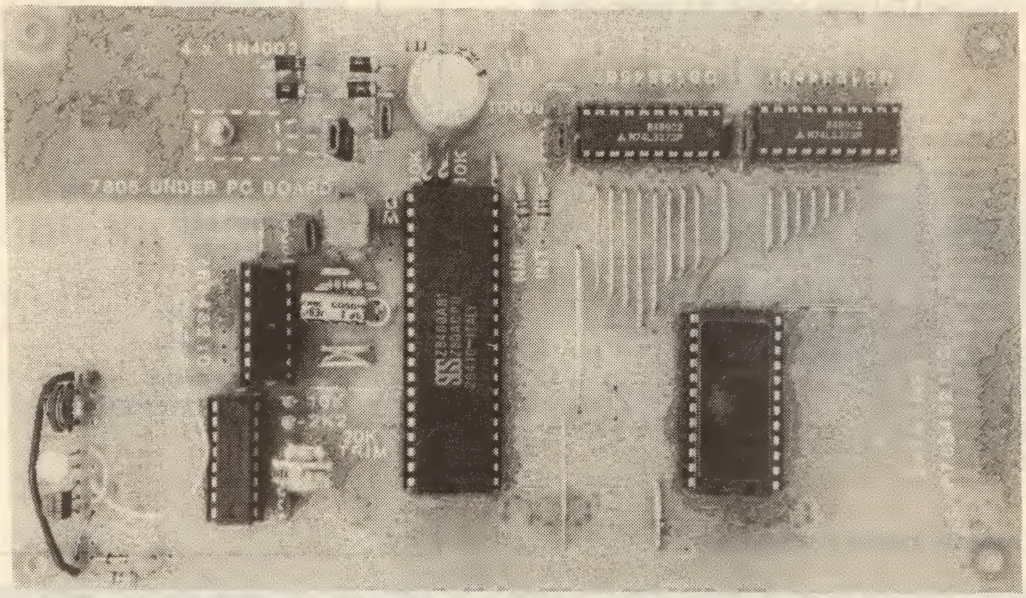
1- 1N4148
2- 1N4002
3- BC547
1- MEL12
1- 40106 Hex Schmitt Inverter
1- 3mm Green LED
1- 3mm Red LED

1- 12v SPDT RELAY
1- 14 pin IC socket
1- SPST toggle switch
1- **TUNNEL STRETCHER PCB**

No.46406 escapes into the evening sun.

COMPUTERS and MODEL RAILWAYS

First seen in Electronics for Model Railways #1, the Dedicated Microcomputer System is back, bigger and better. This is the most complicated project in the book, but don't let that put you off. Its capabilities are remarkable, and well worth the effort required to build it.

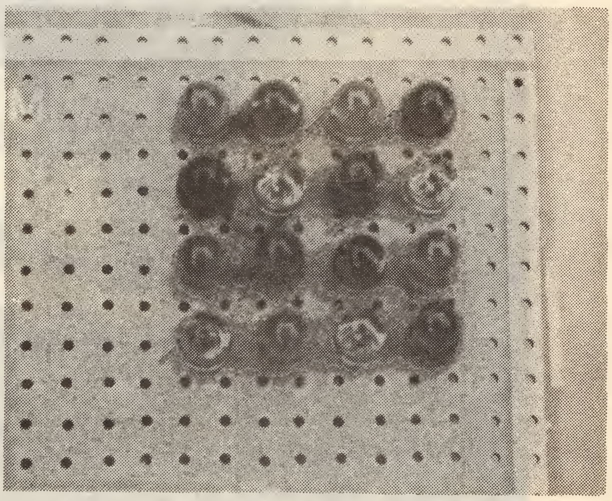


This PCB the heart of the DMS system. It contains all of the components requited to make a small stand alone microcomputer system. Of note are the Reset Button and the two modifications mentioned in the text. The Reset Button is handy if you accidentally "crash" the DMS, causing it to lock up. The only other way to reset the DMS is to turn the power off, then on again.

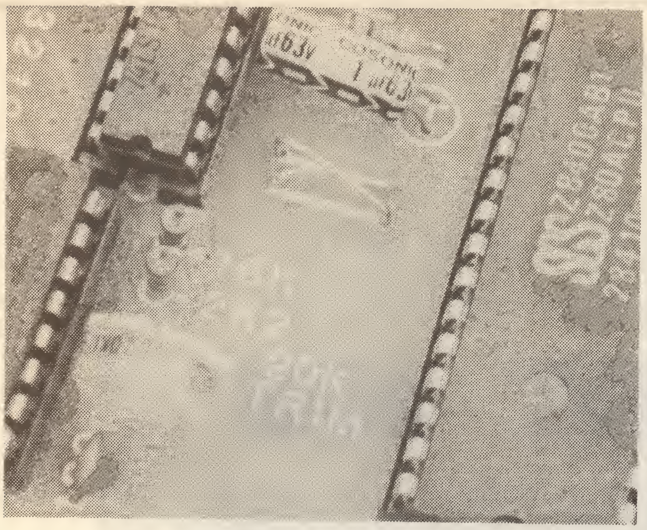
Back in Electronics for Model Railways #1, I presented a preliminary article on a simple, Z80 based, dedicated microcomputer system. It was programmed to do the fairly easy task of looking after a set of traffic lights on a single intersection. Of course, the more adventurous could easily have connected it to the traffic lights from several intersections.

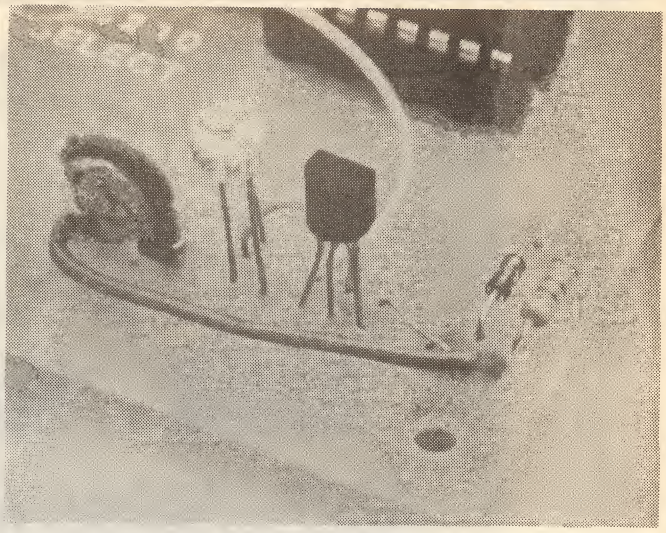
Sure, it was an expensive way to control a set of traffic lights when the sixteen step sequencer was about half the price, but even so, the dedicated micro system has the edge because expansion is easy, and the possibilities are numerous.

People who frequent Melbourne will know the rather fancy sign near Flinders St Station that is used to advertise cola. It has been there for some years now, and still attracts my attention. For those who are not familiar with the sign, it is a large square matrix of lamps. Each "pixel" consists of sixteen lamps in a four by four arrangement. The whole array is a seven by seven matrix of these pixels. That makes seven hundred and eighty four lamps!



The four by four LED matrix that is the display for the advertising sign.





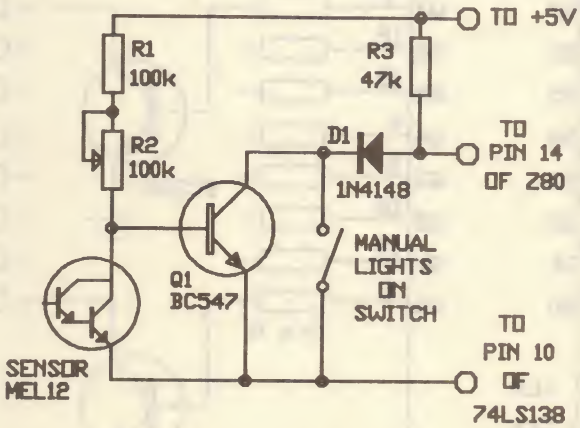
These two photographs show the two modifications that must be made to the Dedicated Microcomputer System PCB. One is to correct a minor mistake. The other is for the light sensor needed by the new program.

This sign displays moving bars, squares, and various other patterns on a programmed cycle. Inspired by this, it was not long before I had a miniature version running on the dedicated micro. Sure, I kept the number of lamps down, and for three good reasons; scale space, complexity, and price. I settled on a four by four matrix. You might think that only sixteen lamps would be rather limiting, but enough variety is possible using them. It also means that as less memory is consumed per sequence step, a longer sequence can be crammed into the dedicated micro's 2k ROM.

I have made several versions of unit and shown them at exhibitions. The smallest is the one detailed here. The largest is about a metre and a half square and is made of old traffic light heads. The response to them is always the same. People are amazed and stand for ages, transfixed by the display.

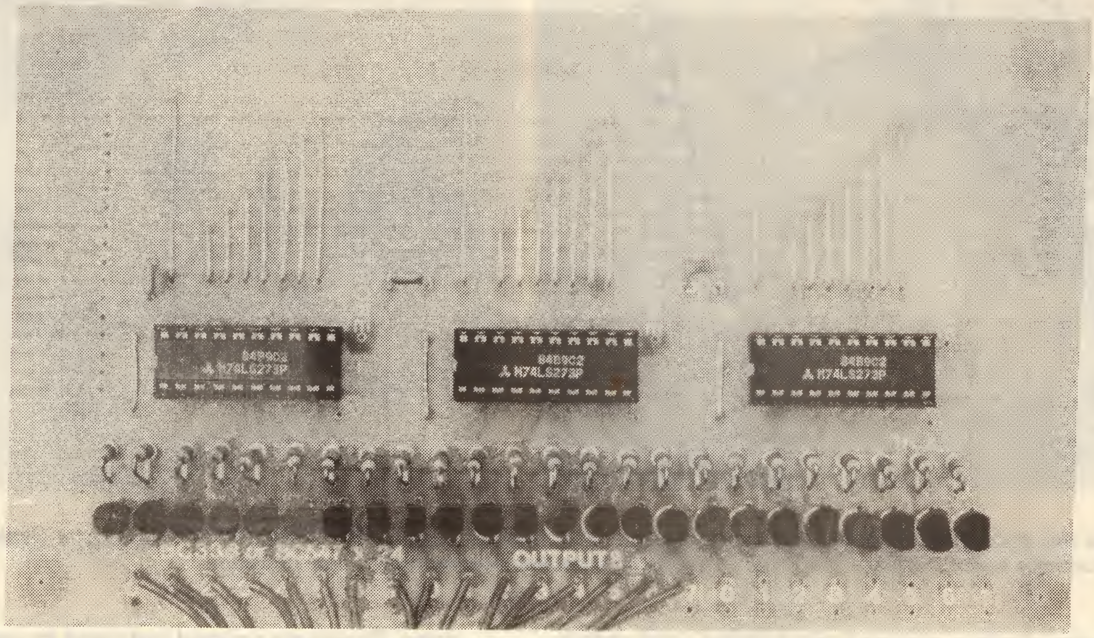
So you want one, but what about the set of traffic lights the dedicated micro is driving at the moment? You still want those to work too. No problems. The program will drive those at the same time. I have included another gimmick in the new EPROM as well. It contains a simple program that monitors a photo-detector and turns on the street lamps when it gets dark. Not only that, it simulates the fluorescent lamp starting effect as well. However, with all the street lamp replacements that have been happening around the suburb where I live, I think a mercury vapour or HPS simulator would have been more appropriate.

One of the eight outputs from the street light simulator is a simple on/off function for controlling any lights that are

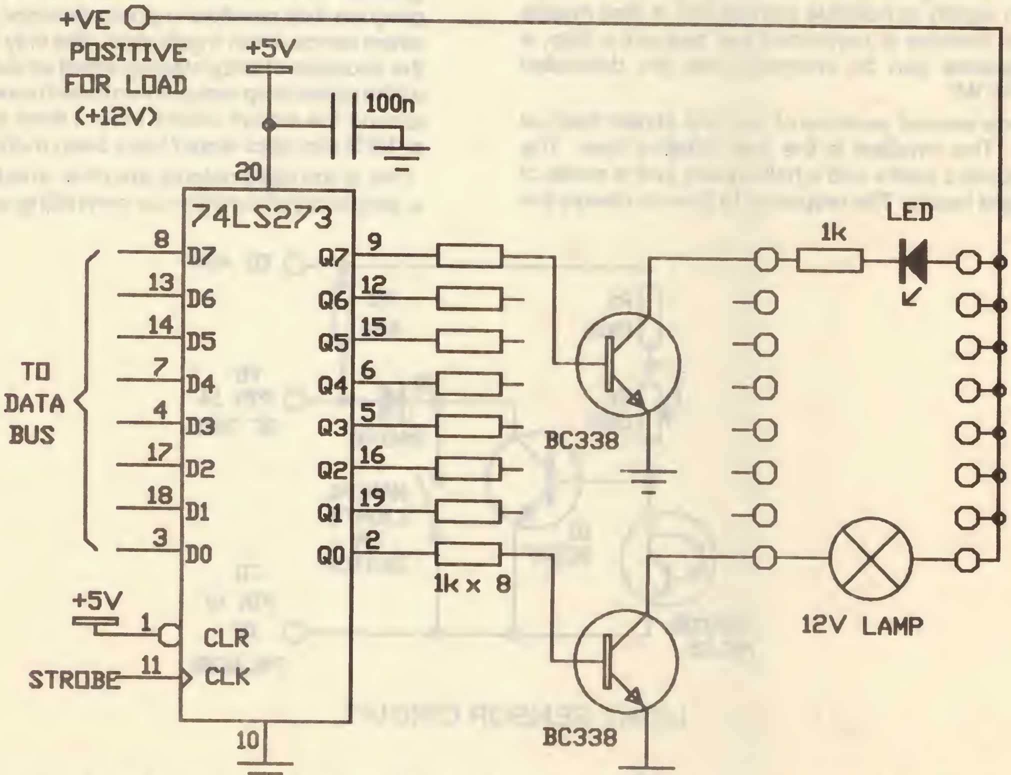


LIGHT SENSOR CIRCUIT.

This is the circuit of the light sensor used by the dedicated micro. R1 and R2 set the sensitivity of the detector. The base of Q1 is connected to them, and is pulled high when there is no light falling on the MEL12. When the program tells the micro to check the sensor, pin 10 of the 74LS138 goes low, giving Q1 and the MEL12 a "zero" volt rail. Because transistor Q1 is switched on, pin 14 of the Z80, which is bit zero of the data bus, is also pulled low. The program reads this and switches the lights on. When light is falling on the MEL12, it holds the base of Q1 low, switching it off when the micro checks the sensor. Pin 14 is held high by R3, telling the program that the lights should be off.



This is the Output Module PCB. The bus and strobe connections are clearly marked on the overlay. You may wire to either end of the bus. Just make sure the data lines are in the correct order. On this PCB, the left and centre latches are used for the four by four sign, while the one on the right is connected to the eight grain of wheat lamps used by the fluorescent lamp simulator.



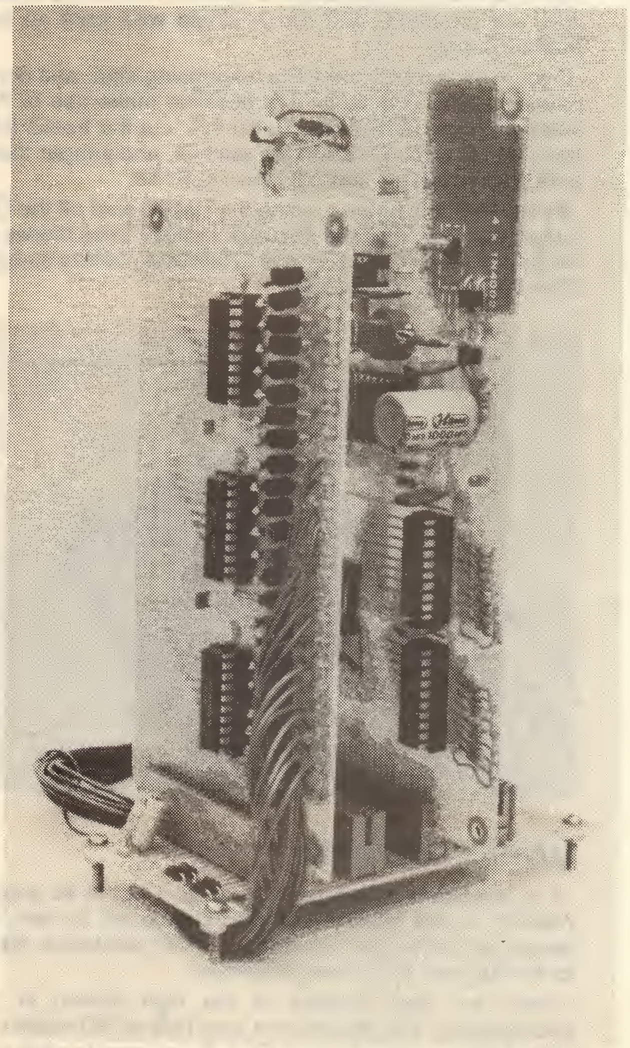
This is a simplified circuit diagram of the output driver module. The transistors and resistors are representative of the twenty four output buffer transistors. Either BC338's or BC547's can be used. The three chips are wired identically so only one is shown. A 74LS374 can be substituted for the 74LS273 if pin 1 is taken to ground instead of five volts. For those not familiar with TTL chips, they must be run on five volts. Most of the chips in the dedicated microcomputer project are TTL, therefore they must be run from a five volt regulator. The one on the DMS board is sufficient for the job.

not fluorescent. Don't limit the simulator to just street lamps either, but for maximum realism, avoid having everything come on at once. A couple of simple delays could be constructed with the 40106 to allow for the "personal initiative" factor involved in switching on station and house lights. See the next project.

CONSTRUCTION

The construction of the dedicated micro computer is detailed in the first volume of Electronics for Model Railways. The parts list, PCB pattern and overlay are repeated in this article, providing enough information for the new constructor. There a couple of modifications that need to be done, too. One of them is for the light sensor that activates the street lamp simulation. It can easily be lashed up on the prototyping area included on the dedicated micro PCB. If you don't want to use the MEL12 opto sensor, just install the switch, diode and 47k resistor.

Don't mount the MEL12 where light from a street lamp can fall on it. It will turn the lights straight back off again! Surprisingly, I have seen some real street lamps that suffer from this problem! They flash on and off at a rate determined by their internal delays.



The completed assembly on the mother board. The spare components on the mother board are not in circuit.

Output Module Parts List

24- 1k 1/4W resistors
3- 100nF capacitors
3- 20 pin IC sockets
24- BC547 or BC338
3- 74LS273 latches
Length of tinned copper wire.
Output Driver Module PCB.

Display Parts List

16- 1k 1/4W resistors
16- Red 3mm LEDs
TE Matrix Board 15x40

DMS Parts List

1- 1k 1/4W resistor
1- 2k2 1/4W resistor
6- 10k 1/4W resistors
1- 47k 1/4W resistor
1- 100k 1/4W resistor

1- 20k trimpot
1- 100k trimpot

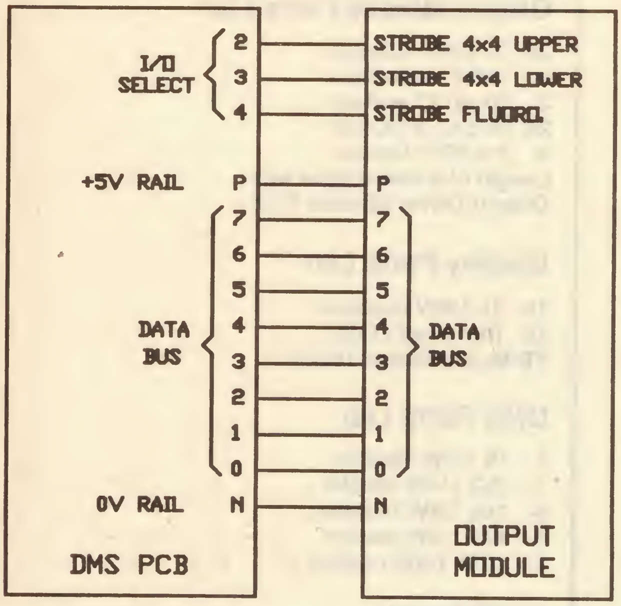
1- 100pF ceramic cap
5- 100nF monoblocks
1- 1uF electrolytic
1- 1000uF electrolytic

1- 1N4148 signal diode
4- 1N4002 power diodes
1- 3mm red LED
1- BC547 transistor
1- MEL12 photo-transistor
1- 7805 regulator
1- CD4049 NOT Fairchild
1- 74LS138 decoder
2- 74LS273 latches
1- Z80 microprocessor
1- 2716 EPROM (programmed)

2- 16 pin IC sockets
2- 20 pin IC sockets
1- 24 pin IC socket
1- 40 pin IC socket
1- reset button
Length of tinned copper wire
Length of hook up wire
Nut & bolt for the regulator
1- DMS PCB

The other modification is to correct a minor mistake. This involves crossing the two links that connect the 74LS138 decoder to the Z80. Doing this will put the I/O select lines from the decoder back in the right order!

A new board has been designed to supplement the dedicated microcomputer. It is the Output Driver Module. It contains three 74LS273 latches, each driving eight transistor buffers, giving a total of twenty four outputs. The software uses eight of these outputs for the street lamp simulator and the other sixteen for the advertising display. Because "open collector" transistor buffers have been used, it is possible to drive lamps of different voltages. All each transistor does is to switch one side of the load (lamp



This is how the two PC boards must be connected, either directly, or via the mother board. Failure to get the order right will, at best, scramble your display. At worst, some components may be damaged. P and N are +5 volts and 0 volts respectively.

or relay) to ground. This means that the other side of the load may be connected to five, twelve or even twenty four volts. Be careful not to go higher than the collector-emitter breakdown voltage (Vce) of the transistors. It is only thirty volts for the BC338, so running at twenty four volts leaves a moderate safety margin.

Assembly should start with the links, of which there are quite a few. For those of you who are wondering why pin one is linked to pin twenty when it could easily have been a PCB track, it is so that the 74LS374 can be substituted for the latch, if required. On this chip, pin 1 must be taken to ground to enable the outputs. Pads have also been provided so this can be done. Next, solder in the chips, taking care with their orientation. You may use sockets if you feel it necessary. Now solder in the three decoupling capacitors.

The twenty four base resistors have been stood on end to conserve space. Try to keep them, and the transistors, at an even height for aesthetic reasons. The transistors may be either BC547's (100mA) or BC338's (800mA) depending on the load you wish to drive. Grain of wheat bulbs draw about 45ma each when run on 12 volts. The other thing to remember when connecting loads to transistors is dissipation. The BC338 is rated at 500mw at 25 degrees C. This value drops as the transistor's case temperature rises. The dissipation can be simply worked out by measuring the voltage across the collector and emitter of the transistor and multiplying it first by the current through it, then by the duty cycle at which it is being switched. In other words, a transistor that is on for only half the time can handle twice the load as one that is on all the time, assuming the frequency of switching is under a couple of minutes per cycle. This is an extremely simplified look at dissipation, but should be sufficient for the modeller, who I am sure doesn't want to know about derating curves! If you want to switch a larger load, use a relay. Dissipation can be ignored.

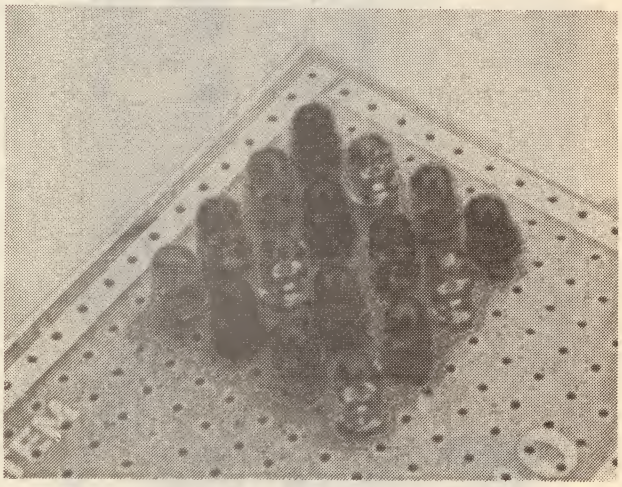
The two printed circuit boards may be connected together in several ways, depending on finance and requirement. In the photograph on page 35 you will see that a small "mother board" or back plane has been used. This board is the Designer Board "Mother Board" from Talking Electronics. Edge connectors also need to be purchased, and they can be expensive. Doing it this way does allow easy board removal for modification or repair. The three decoder outputs on the DMS PCB need to be wired the board's edge. There are plenty of spare edge strips. The "strobe" inputs of the latches will also need to be similarly wired, making sure that the edge strips selected correspond to the ones used on the DMS board.

The other, and much cheaper way is simply to wire the buses of the two boards together using the holes provided. P to P, 0 to 0, 1 to 1, and so on. The three strobe inputs are wired directly to the decoder outputs.

The hole marked "+VE" on the output module is connected to the row of pads that runs along the side of the transistors. The row of pads is there only as a convenient place to common lamp wires. Its use is not essential. More often than not, it will be easier to common the lamps where they are mounted, and run a single wire back to the positive supply.

If you only want to make the advertising sign, and don't need the other functions, it is possible make use of the latches on the DMS PCB. To do this, cut the tracks that connect the strobe lines to the latches, and jumper them to I/O select lines 2 and 3 on the 74LS138.

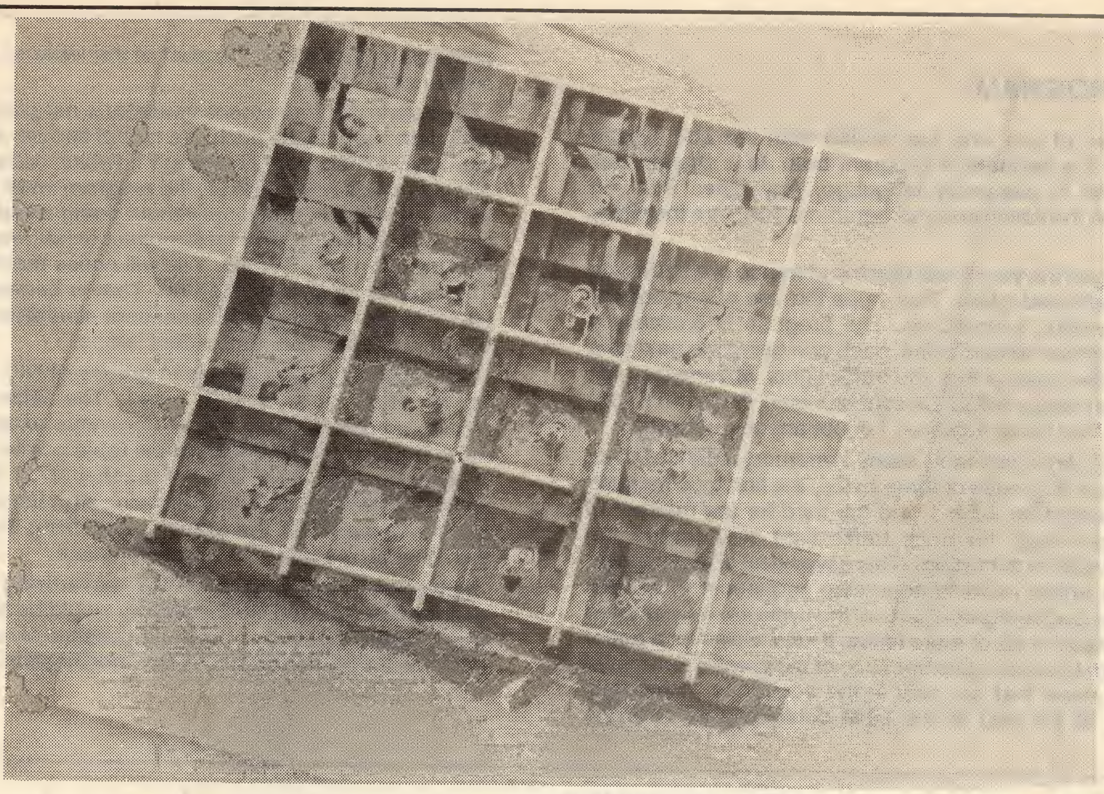
If you are planning on running the DMS board off the DC supply that is feeding the displays, remove three diodes of the bridge rectifier, leaving one to feed the positive supply. Directly connect the 0v line.



MAKING THE SIGN

It is important to get each lamp or LED in its proper position, or the full effect of the patterns will be lost, the lamps just flashing in a pseudo-random sequence. Refer to the diagram for correct placement.

There are two versions of the sign shown in the photographs. The smaller one was built in HO scale and uses various colored 3mm LEDs. It was constructed on a piece of Talking Electronics matrix board. The LEDs can be lined up to shine through a small square matrix. Suitable ones can be bought at a hardware shop. They are used to



This is a close up of the display that was made using grain of wheat lamps. Each lamp is in its own little box, which is part of the fluorescent light baffle. The whole assembly is sandwitched between two pieces of clear plastic and uses a sheet of white paper as a difuser.

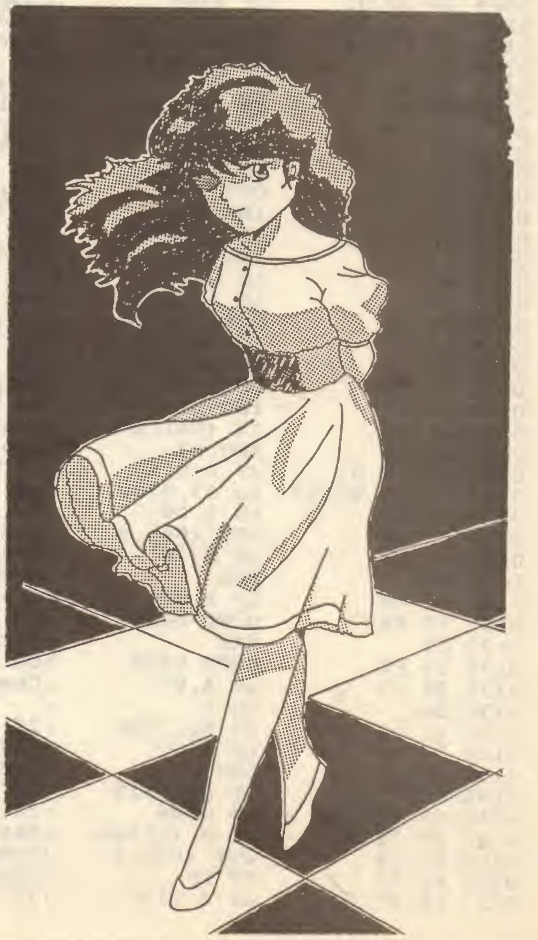
hold the plastic inserts or "star plugs" used when screwing things to brick walls. You might have to search for older stocks because lately they are being sold in plastic bags.

The LED resistors can be mounted on the LED Resistors board from the last book, or put on the Matrix board that is left after the display has been cut from it. If there is enough space in your model, they can even be soldered directly onto the back of the LEDs, as shown in the photograph.

The larger of the displays shown is for "real" advertising at exhibitions. It uses grain of wheat bulbs. A section of baffle from a fluorescent shop light has been used to give each lamp its own little square. The assembly is sandwiched between two pieces of clear PVC. Ordinary paper is used across the top of the baffle as a diffuser. A colored filter or advertising picture can be hidden behind the paper, becoming visible only when the lamps are on.

For the adventurous, the sign can be further expanded just by adding more four by four groups of LEDs or lamps in parallel with those already there. Any extra LEDs will require their own current limiting resistors. If you try to parallel LEDs on the same resistor, there is a good chance that only one of them will light. If they both light, they are sure to be of different brightnesses. The pattern can be reflected or rotated to give variation to the display.

Undoubtedly some wise-guy will use the display as a scale disco floor. I get enough comments about it.



THE PROGRAM

For those of you who are familiar with the Z80, I have provided the sequencer program both as a straight hex dump and in assembly language. Any bytes that are skipped in the listing are unprogrammed and are therefore FF.

The program is very linear due the absence of a RAM chip in the dedicated micro. This stops the use of any calls or stack handling instructions. The program is basically a series of three nested loops, each one using the next as a "delay". Because of this, the traffic lights, advertising sign and street lamps will all be synchronised, but even if they are mounted close together, I doubt anyone will notice.

The traffic light data table starts at memory location 01A0. The data is in groups of three bytes, the first byte for latch 0, the second for latch 1 and the third for the number of sequencer steps for each traffic light step (called the DELAY value in the listing). This saves a lot of table space, because unlike in the sixteen step sequencer in the last book, the long red/green parts of the cycle are only entered once instead of six or more times. It also allows for a better red/green to amber ratio because of the greater number of smaller steps that are now in the sequence. A memory location at the end of the table containing FF tells the program to go back to the start of the table to repeat the sequence.

The data in the fluorescent simulator is not grouped, each byte being sent to the latch at a rate of two per advertising sign step. When a byte reading FF (which corresponds to all lights on) is encountered, the program instantly returns to the advertising sign loop without doing anything further to the street lamps. The table pointer is not reset until the lights are turned off again. You will notice that the data in this table is all greater than 80. That is because bit 7 is HIGH for the duration of fluorescent simulation so it can be used to drive non-fluorescent lamps.

The advertising sign data is in groups of two bytes, one bit for each lamp or LED used. The table length is monitored differently to the two previous examples. The most significant byte (MSB) of the table pointer (held in D register) is monitored. When it reaches 07, it is reloaded with 02. The table for the advertising sign fills exactly five eighths of the ROM, the rest of it containing the program, the other tables and some unused space.

Multiplexing the output of the advertising sign was deliberately avoided, so the display would be brighter and free of flickering. It also makes it possible to run different types of lamps without any driver modification.

DMS Assembly Language Program Listing

```
0000 FD 21 00 07  LD IY,0700     ;Load Fluoro. pointer with table start
0004 C3 00 01     JP 0100        ;Jump to program start
0100 11 00 02     LD DE,0200     ;Load Seq. pointer with table start
0103 21 A0 01     LD HL,01A0     ;Load Traf. pointer with table start
0106 7E           LD A,(HL)      ;Get Traf. data from table
0107 FE FF        CP FF          ;FF indicates the end of the data
0109 28 F8        JR Z,0103      ;If FF then go back to 0103
010B D3 00        OUT (00),A     ;Output the data to latch 0
010D 23           INC HL         ;Go to next table location
010E 7E           LD A,(HL)      ;Get second Traf. data from table
010F D3 01        OUT (01),A     ;Output the data to latch 1
0111 23           INC HL         ;Go to next table location
0112 7E           LD A,(HL)      ;Get DELAY data from table
0113 23           INC HL         ;Go to next table location (for later)
0114 4F           LD C,A         ;Put DELAY value in C register
0115 1A           LD A,(DE)      ;Get adv. sign data
0116 D3 02        OUT (02),A     ;Output the data to latch 2
0118 13           INC DE         ;Go to next table location
0119 1A           LD A,(DE)      ;Get second adv. sign data
011A D3 03        OUT (03),A     ;Output the data to latch 3
011C 13           INC DE         ;Go to next table location (for later)
011D DB 05        IN (05),A      ;Read photo-cell or switch.
011F E6 01        AND 01         ;Separate data and check.
0121 CA 50 01     JP Z 0150      ;If DARK, jump to 0150 to turn on lights
0124 FD 21 00 07  LD IY,0700     ;If light, reset Fluoro table
0128 3E 00        LD A,00        ;Turn off lights by loading A with 00
012A D3 04        OUT (04),A     ;and sending out to latch 4
012C 06 10        LD B,10        ;Start 1 step delay loop
012E D9           EXX            ;Exchange registers (save B)
012F 06 00        LD B,00        ;Start internal loop
0131 10 FE        DJNZ 0131      ;Go to 0131 until B is 00 again
0133 D9           EXX            ;Exchange registers (recover B)
0134 10 F8        DJNZ 012E      ;Go to 012E until B is 00
0136 3E 07        LD A,07        ;Check for end of adv. table
0138 BA           CP D           ;
0139 20 02        JR NZ,013D     ;If not end of table, jump to 013D
013B 16 02        LD D,02        ;Reload pointer with table start
013D 0D           DEC C          ;Reduce and check cycles in DELAY
013E C2 15 01     JP NZ 0115     ;If DELAY not over, go to 0115
0141 C3 06 01     JP 0106        ;If DELAY over, go to 0106 (get next table value)
0150 FD 7E 00     LD A,(IY+00)   ;Get Fluoro data
0153 D3 04        OUT (04),A     ;Output the data to latch 4
0155 FE FF        CP FF          ;Check if all lamps are on (FF)
0157 CA 2C 01     JP Z 012C      ;If they are, go back to 012C
```

```
015A FD 23        INC IY            ;Go to next table location
015C 06 08        LD B,08           ;Start 1/2 step delay loop
015E D9           EXX               ;Exchange registers (save B)
015F 06 00        LD B,00           ;Start internal loop
0161 10 FE        DJNZ 0161         ;Go to 0161 until B is 00 again
0163 D9           EXX               ;Exchange registers (recover B)
0164 10 F8        DJNZ 015E         ;Go to 015E until B is 00
0166 FD 7E 00     LD A,(IY+00)      ;Get Fluoro data
0169 D3 04        OUT (04),A        ;Output the data to latch 4
016B FD 23        INC IY            ;Go to next table location (for later)
016D 06 08        LD B,08           ;Start 1/2 step delay loop
016F D9           EXX               ;Exchange registers (save B)
0170 06 00        LD B,00           ;Start internal loop
0172 10 FE        DJNZ 0172         ;Go to 0172 until B is 00 again
0174 D9           EXX               ;Exchange registers (recover B)
0175 10 F8        DJNZ 016F         ;Go to 016F until B is 00
0177 C3 36 01     JP 0136           ;Go to 0136
```

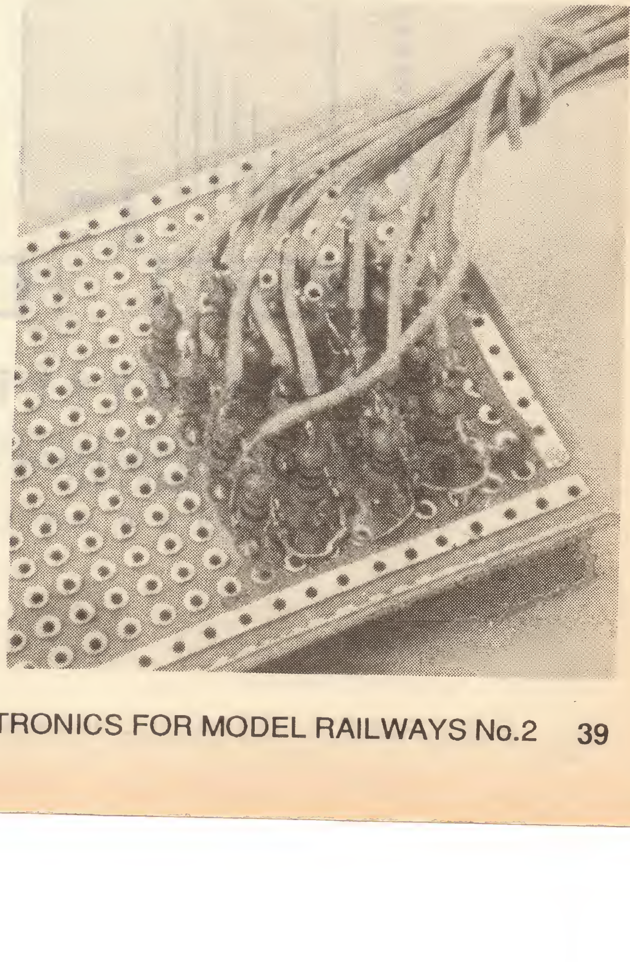
3	2	1	0	TO LATCH 02
7	6	5	4	
3	2	1	0	TO LATCH 03
7	6	5	4	

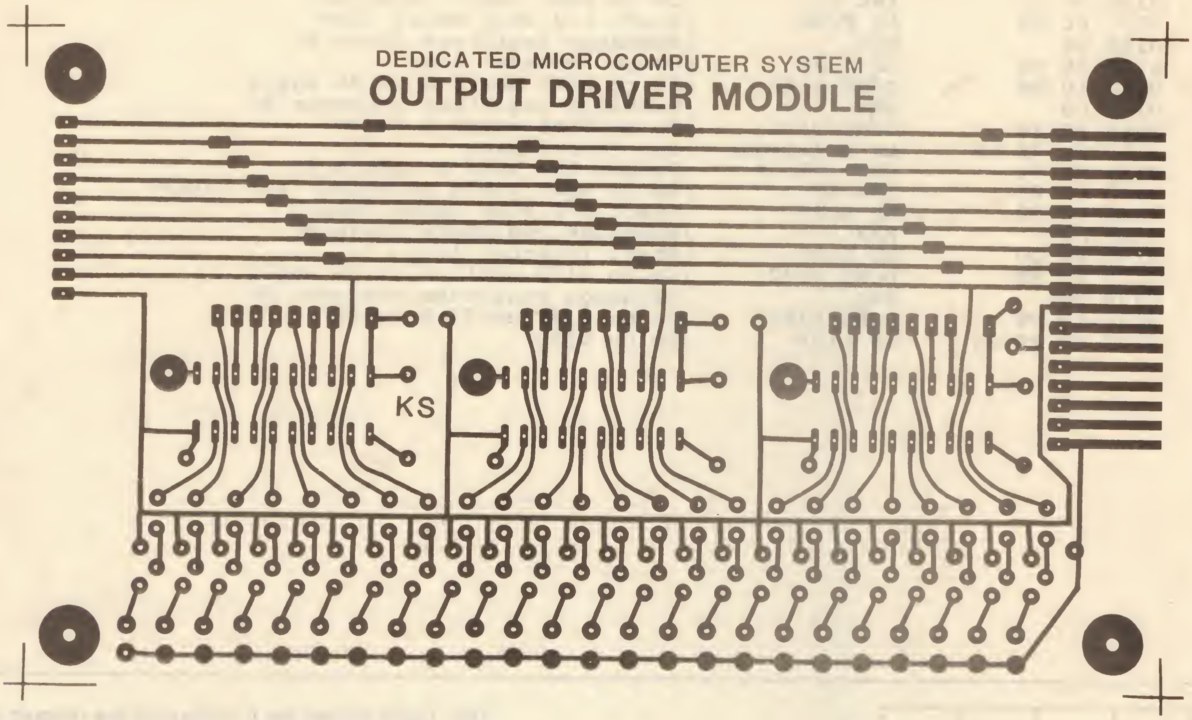
OUTPUT BITS AS
MARKED ON PCB

This diagram shows the way the LEDs or lamps must be set out when you are building the advertising sign. The numbers in the boxes correspond to the numbers on the PCB near each output driver transistor. Latch 2 and latch 3 are distinguished only by the I/O select line to which they are connected. Failure to position the lamps correctly will result in a pseudo random pattern. It will still be interesting to watch, but the impact of the carefully designed sequences will be lost.

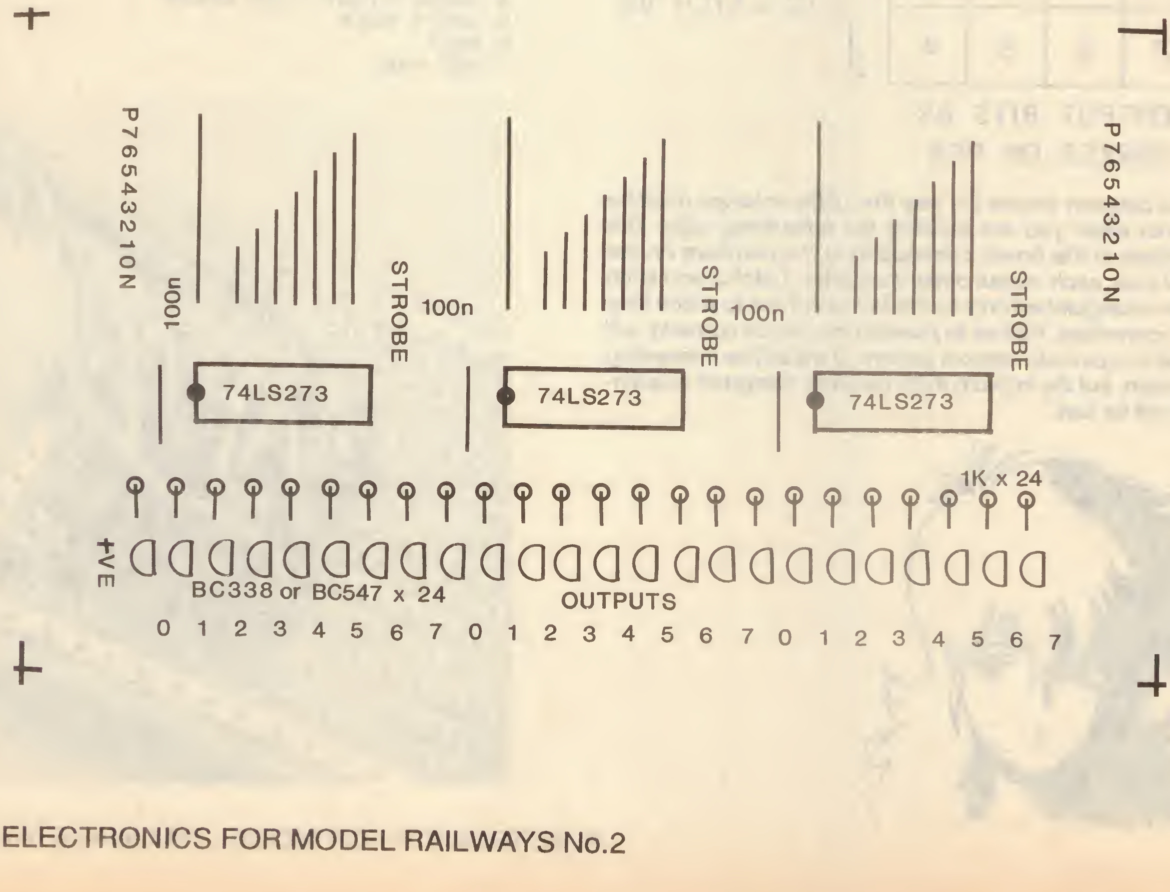
This Table shows the functions of the outputs of the two latches used used for the traffic lights. The output of one latch is for North-South traffic, while the other is for East-west traffic.

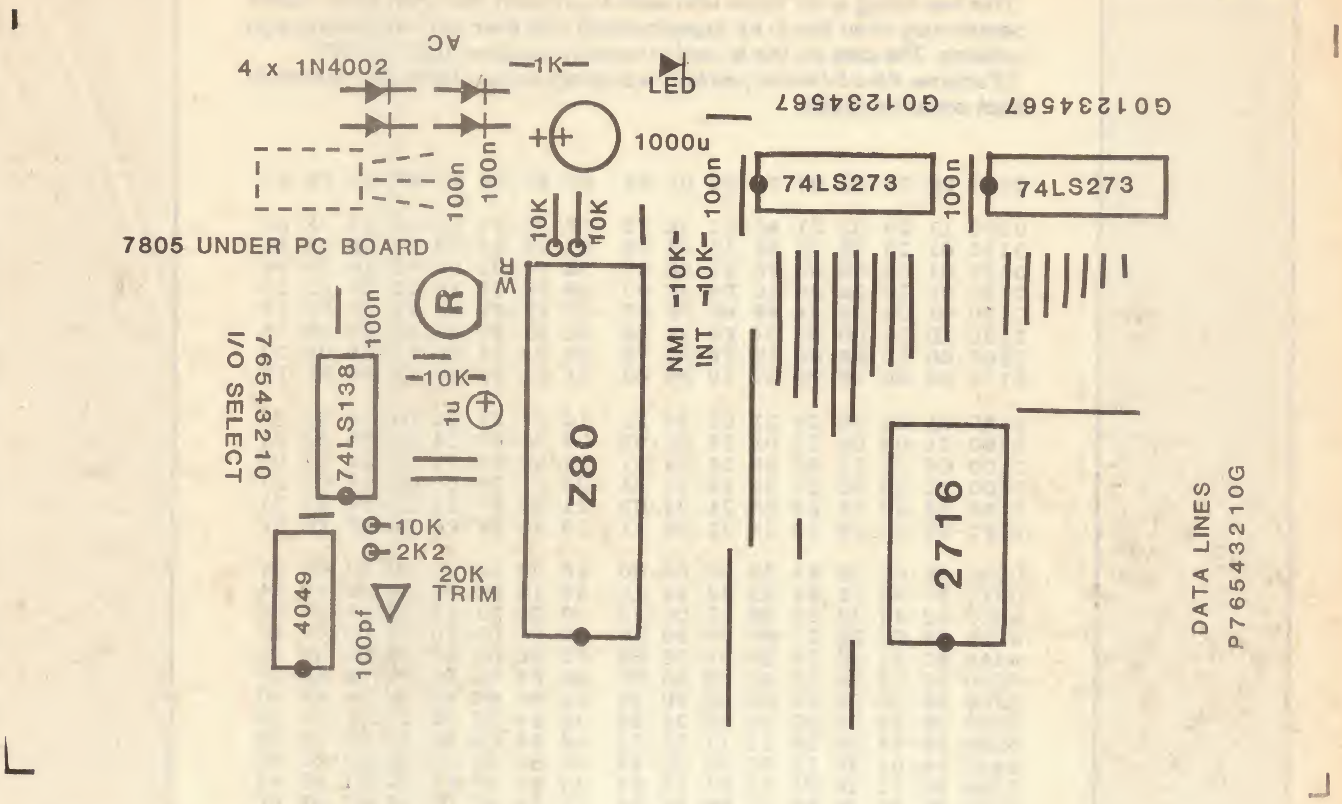
```
0 RED
1 AMBER
2 GREEN
3 AMBER RIGHT TURN ARROW
4 GREEN RIGHT TURN ARROW
5 DON'T WALK
6 WALK
7 NOT USED
```



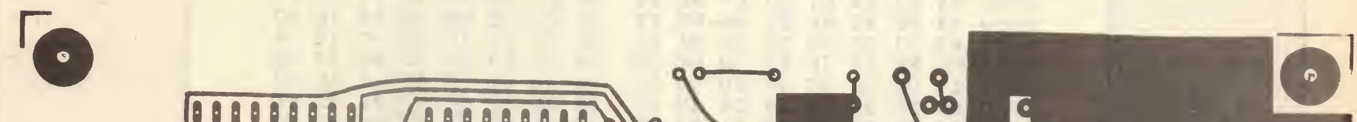


Above and below are the PCB pattern and overlay for the Output Driver Module. Refer to them when you are assembling the board. Note that the PCB pattern is as seen from below.





Above and below are the PCB pattern and overlay for the Dedicated Microcomputer System CPU board. Along with the parts list and notes in the article, these diagrams should provide new constructors with enough information to successfully build the unit. For those who feel they require it, the circuit diagram is in Electronics for Model Railways Vol#1.



This hex listing is for those who wish to program their own ROM. Some people may even like to try experimenting with their own advertising sign patterns. The data for this is held in memory locations 0200 to 06FF.

Of course, it is a lot easier just to by a preprogrammed ROM. See the inside back cover for details.

```
0000 FD 21 00 07 C3 00 01 FF  FF FF FF FF FF FF FF FF

0100 11 00 02 21 A0 01 7E FE  FF 28 F8 D3 00 23 7E D3
0110 01 23 7E 23 4F 1A D3 02  13 1A D3 03 13 DB 05 E6
0120 01 CA 50 01 FD 21 00 07  3E 00 D3 04 06 10 D9 06
0130 00 10 FE D9 10 F8 3E 07  BA 20 02 16 02 0D C2 15
0140 01 C3 06 01 FF FF FF FF  FF FF FF FF FF FF FF FF
0150 FD 7E 00 D3 04 FE FF CA  2C 01 FD 23 06 08 D9 06
0160 00 10 FE D9 10 F8 FD 7E  00 D3 04 FD 23 06 08 D9
0170 06 00 10 FE D9 10 F8 C3  36 01 FF FF FF FF FF FF

01A0 21 21 05 23 21 05 44 21  14 24 21 03 04 21 03 24
01B0 21 03 04 21 03 24 21 03  04 21 03 24 21 05 22 21
01C0 06 21 21 05 29 21 04 31  21 0B 29 21 05 21 21 05
01D0 21 23 05 21 44 14 21 24  03 21 04 03 21 24 03 21
01E0 04 03 21 24 03 21 04 03  21 24 05 21 22 06 21 21
01F0 05 21 29 03 21 31 0B 21  29 05 FF FF FF FF FF FF

0200 60 06 9F F9 99 0F F9 00  0F 00 00 00 00 80 00 84
0210 20 84 21 84 22 44 44 22  48 12 C0 03 30 0C 21 84
0220 22 44 44 22 48 12 C0 03  30 0C 21 84 23 C4 67 E6
0230 6F F6 EF F7 FF FF F0 FF  00 FF 00 F0 00 00 08 10
0240 8C 31 9E 79 9F F9 0F F0  F0 0F 00 00 09 00 99 00
0250 99 09 99 99 90 F9 00 FF  60 F6 66 66 66 06 66 00
0260 06 00 00 00 00 60 00 66  60 66 66 66 6F 06 6F 00
0270 0F 00 09 00 00 00 88 88  44 44 22 22 11 11 22 22
0280 44 44 88 88 11 11 22 22  44 44 88 88 01 00 12 00
0290 24 01 48 12 80 24 00 48  00 80 00 C0 00 E0 00 F0
02A0 00 F1 10 F1 11 F1 13 F1  17 F1 1F F1 9F F1 9F F9
02B0 9F FD 9F FF BF FF FF FF  FF FF FF 0F FF F0 0F FF
02C0 F0 FF FF FF EF FE CF FC  8F F8 0F F0 1E E1 3C C3
02D0 78 87 F0 0F F1 1F F3 3F  F7 7F FF FF F7 FF F3 FF
02E0 F1 FF F0 FF E0 FF E0 FE  E0 EE E0 CE E0 8E E0 0E
02F0 E0 06 60 06 20 06 00 06  00 04 00 00 60 06 40 06

0300 44 07 56 07 57 07 AE 0E  E0 EA 70 75 70 77 71 F7
0310 73 FF F7 FF FF FF FE FF  CD FF BB F8 77 07 76 07
0320 45 07 33 00 32 00 01 00  00 00 18 18 3C 3C 7E 7E
0330 FF FF FF 7F FF 7B DF 7B  DB 7A D3 6A 53 4A 53 02
0340 13 00 01 00 00 10 00 33  70 56 CE 1A 48 12 48 02
0350 E0 00 42 08 44 04 48 02  E0 00 42 08 03 88 03 C0
0360 06 60 0C 30 88 11 90 09  30 0C 60 06 44 22 46 62
0370 47 E2 57 EA D7 EB DF FB  DE 7B FE 7F FD BF FB DF
0380 F7 EF 7F FE EF F7 FE 7F  FD BF FB DF F7 EF 7F FE
0390 EF F7 FE 7F FC 3F F8 1F  F0 0F 70 0E 60 06 60 0F
03A0 60 9F 00 9F 00 99 00 90  00 91 10 91 11 91 13 91
03B0 17 91 1F 91 E0 A2 00 CC  00 80 00 80 00 C0 00 E0
03C0 00 F0 00 70 00 30 00 10  00 11 10 11 11 11 11 01
03D0 11 00 01 00 21 00 21 04  21 84 20 84 00 84 00 80
03E0 00 88 80 88 80 08 80 00  C0 00 E0 00 F0 00 70 00
03F0 30 00 10 00 11 00 01 00  13 00 17 01 1F 11 1E 11

0400 0C 11 08 10 88 30 88 78  88 F8 80 E8 00 C8 00 80
0410 00 80 00 C8 80 EC C8 FE  EC FF FE FF FF FF DE 7B
0420 8C 31 08 10 00 00 09 00  9F 00 FF 09 FF 9F FF FF
0430 EE 77 CC 33 F0 0F 33 CC  66 66 CC 33 F0 0F 33 CC
0440 66 66 CC 33 F0 0F 33 CC  66 66 62 46 22 44 21 84
0450 30 0C C0 03 48 12 44 22  22 44 21 84 30 0C C0 03
0460 48 12 44 22 22 44 21 84  31 8C F0 0F E0 0E D0 0D
0470 B0 0B 70 07 F0 0F 70 0E  60 06 40 02 00 00 00 00
0480 00 10 00 00 00 10 00 00  00 33 00 00 00 33 00 00
0490 70 77 00 00 70 77 00 00  FF FF 00 00 FF FF 5A 5A
04A0 FF FF A5 A5 FF FF 5A 5A  FF FF A5 A5 A5 B5 A5 B7
04B0 E5 B7 ED B7 EC 37 CC 33  8C 31 8E 71 0E 70 0F F0
04C0 07 E0 03 C0 01 80 00 00  20 00 57 07 88 F8 00 00
04D0 20 00 57 07 88 F8 00 00  20 00 77 07 FF FF FF FF
04E0 FF 7F FF 37 7F 13 37 01  13 00 01 00 00 00 00 20
04F0 00 22 20 02 22 20 06 22  2C 02 AA 20 86 2A 2C 8A

0500 AA A0 86 2A 2C 8A AA A0  86 2A 2C 8A AA A0 86 2A
0510 2C 8A AA 80 86 08 0C 88  88 80 80 08 00 88 00 80
0520 00 00 0C 30 CC 33 F0 0F  33 CC 66 66 CC 33 88 11
0530 00 00 80 01 C0 03 C4 23  44 22 04 20 00 00 00 F0
```

```
0540 00 FF F0 FF FF FF F7 FF  73 FF 31 F7 10 73 00 31
0550 00 10 00 00 11 11 33 33  77 77 FF FF F0 FF 00 FF
0560 00 F0 00 00 01 80 21 84  21 84 70 0E A4 25 62 46
0570 21 84 70 0E A4 25 62 46  21 84 70 0E A4 25 64 45
0580 24 85 24 0F A4 25 A2 26  A1 24 F0 24 A4 25 A2 26
0590 A1 24 F0 24 A4 25 A4 25  22 0E 21 84 70 44 A4 25
05A0 22 0E 21 84 70 44 A4 25  22 0E 21 86 10 42 00 23
05B0 00 12 00 30 00 21 00 22  00 24 00 06 20 04 40 04
05C0 80 04 C0 00 84 00 88 00  80 00 08 00 00 00 01 80
05D0 01 80 13 C8 13 C8 B7 ED  B7 ED FF FF FF FF DE 7B
05E0 DE 7B 8C 31 8C 31 08 10  08 10 00 00 00 00 02 00
05F0 22 00 22 02 20 22 40 12  00 07 10 42 20 22 40 12

0600 48 02 E0 00 42 08 44 04  40 44 00 44 00 48 00 E0
0610 00 42 02 44 12 48 30 C0  50 0A 90 09 A0 05 C0 03
0620 84 21 44 22 24 24 06 60  42 42 44 22 48 12 30 0C
0630 50 0A 90 09 A0 05 C0 03  84 21 88 11 80 01 08 10
0640 00 00 04 20 40 02 60 00  60 80 61 08 F0 00 42 08
0650 44 04 48 02 E0 00 42 08  44 44 48 21 F0 00 21 84
0660 42 84 88 88 80 93 00 F0  00 C3 21 84 42 84 44 88
0670 88 88 80 88 00 80 00 81  40 81 40 A1 42 A1 C2 A1
0680 E2 A1 E2 E1 EA E1 EE E5  FE E5 FE ED FE FD FE FF
0690 FF FF FE FF FF FF FE FF  FF FF CC FF FF FF CC FF
06A0 FF FF 88 F8 FF FF 88 F8  FF FF FF FF 48 02 C4 02
06B0 22 0E 21 86 10 42 00 23  00 12 00 23 10 42 21 86
06C0 22 0E C4 02 48 02 C4 02  22 0E 21 86 10 42 00 23
06D0 00 12 00 23 10 42 21 86  22 0E C4 02 48 02 C4 02
06E0 22 0E 21 86 10 42 00 23  00 12 40 12 48 12 C0 03
06F0 50 0A 60 06 62 46 63 C6  73 CE F3 CF FB DF FF FF
0700 A5 82 C8 94 A1 D0 AB C4  93 E8 D6 C9 E6 DB E7 DB

0710 FB F7 FF FF FF FF FF FF  FF FF FF FF FF FF FF FF
```

DELAY MODULE

Although it can't do a great deal by itself, this accessory will come in handy any time you need a short delay in the control circuits of your layout, be it turning on lights, controlling crossing gates, or just stopping something from powering up before another part of the circuit is ready.

A trackside shed. Its lights come on a short while after all the street lamps. The small "light bulb" that hangs from the verandah roof is in fact a small LED.

This circuit is really just a building block or accessory. By itself, its uses are limited. All it does is to provide two delays with transistor buffered outputs, each of several seconds. The delays are totally independent of each other though they can be cascaded. The outputs can be used to drive lamps, LEDs, or with the addition of a diode, relays. Each delay's turn off time is the same as its turn on time.

So what can it be used for? Remember my comment in the Dedicated Microcomputer System article on the use of personal initiative delays for switching on and off house and station lights when your street lights come on automatically. This board will do the job. It contains the transistor to CMOS interface required to connect it to the buffered transistor outputs of the DMS Output Module. In fact, it can be connected to the NPN transistor buffers on many of the circuits presented in this book.

The delays can also be used in conjunction with the Servo Driver circuit when a set of crossing gates (not boom gates) is being modelled. If the gates you have are across a double line, you probably won't have a problem, but if you have them across a single line, the gates must be opened or closed one at a time, or they will hit each other. If the delay is put between the driver for the servo on one gate and the driver for the servo on the other, it is possible to have the gates open and close one at a time automatically.

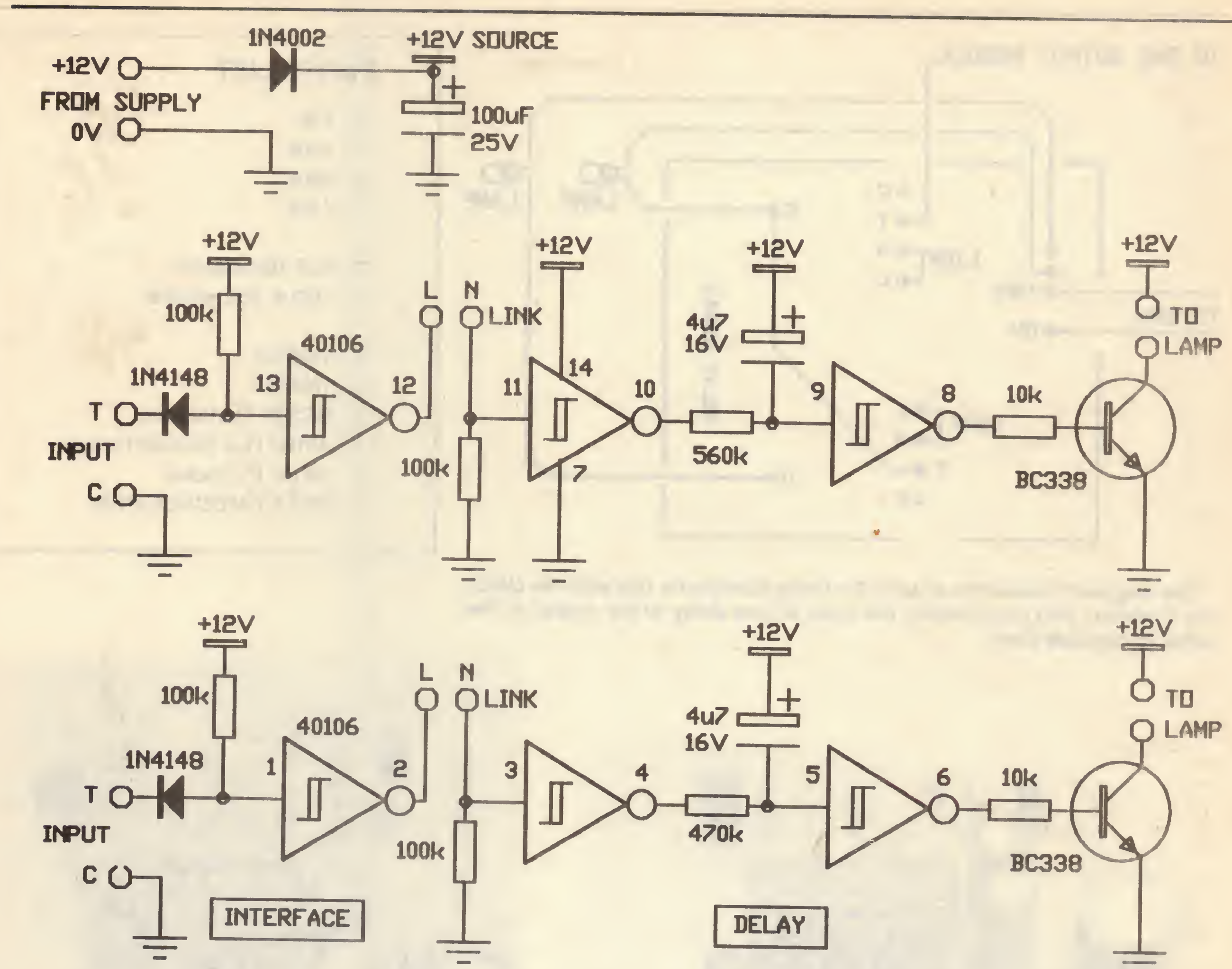
ABOUT THE CIRCUIT

The delay module consists of two almost identical circuits. The only difference is the value of the delay resistor. In the upper delay it is 560k. In the lower one it is 470k. Of course another value can be substituted for this resistor if a different length delay is required.

The delays each have a dual input circuit, allowing them to be interfaced directly to a CMOS control signal or to a transistor buffered output. The input mode is selected by a link. If a CMOS control signal is being used, it is fed directly into the delay at the pad marked "N". The pad marked "C" is for the common or 0V line that must also be used unless the circuits are running on the same power supply.

If the delay is being driven by a transistor buffer such as an output on the DMS output module, the other input is used. It is the pad marked "T" (for transistor). When this input is used, a link must be soldered between the pads marked "N" and "L".

When an NPN transistor buffer is switched on, the collector of the transistor is very close to 0V. This means that we



The Delay Module Circuit.

have a 0V level for the "ON" condition, which is back to front for the positive logic (HIGH = ON) that the delay uses. This negative logic "ON" state is converted to positive logic by the "interface" inverter before being fed to the delay. The diode and 100k pull-up resistor allow the module to be used in conjunction with drivers that are running off a supply voltage greater than 12V. However if the voltage the driver is being run off is less than about 9V, the interface will not work in some cases, seeing the input as a constant LOW.

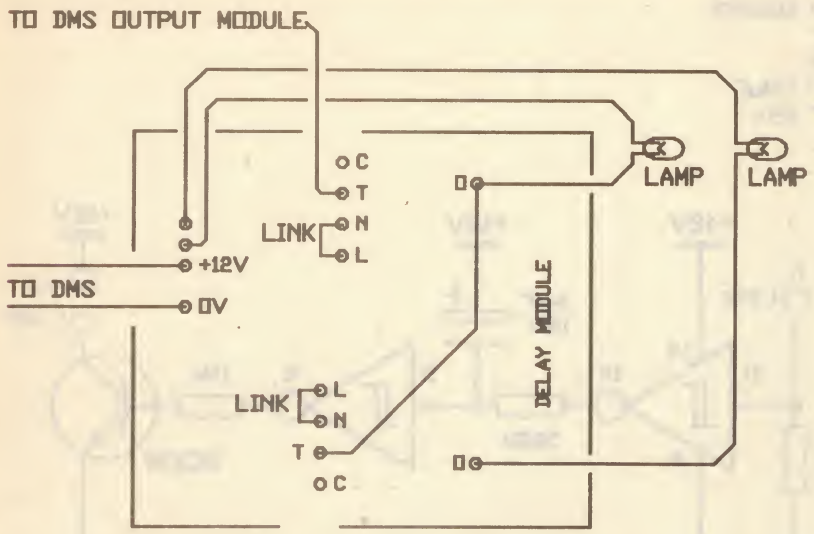
When a HIGH is put on the "N" input of the delay by either an external source or the interface, the output of the first delay inverter will go low and start to charge the 4u7 electrolytic capacitor via the 560k resistor. When the voltage across the capacitor reaches about 8V, the output of the second inverter in the delay will go HIGH, switching on the output transistor. The capacitor will continue to charge until it has almost 12V across it but no further changes will occur at the output.

When input "N" of the delay goes LOW again, the output of the first inverter in the delay will go HIGH. The capacitor will now discharge through the 560k resistor. When the voltage at the input of the second inverter in the delay reaches about 8V, its output will go LOW again and switch off the output transistor. C1 will continue discharging until there is almost 0V across it.

The reason the capacitor is connected between the 12V rail and the input, rather than the more common 0V to input arrangement is to do with how the circuit starts when power is first applied. The input to the delay is most likely to be LOW on power up, and thus the output of the first inverter in the delay will initially be HIGH. This would normally discharge the capacitor but since the capacitor will not yet have been charged, it will already be holding the input to the second inverter HIGH. All this means is that the delay will start in the OFF condition. If the capacitor was referenced to the 0V rail, there would be strange occurrences, such as crossing gates opening and closing, while the capacitor charged.

CONSTRUCTION.

The delay module is built on a printed circuit board measuring 56mm by 48mm. Start construction with the lower components such as the resistors and the socket. Take care withe the orientation of the capacitors, diodes and the chip, when you finally insert it in the socket. The 40106 is CMOS, so try to avoid handling the pins of the device as it is susceptible to static. If you intend to connect the Delay Module inputs to the transistor buffered outputs of another project, make sure you remember to link the "L" and "N" pads in each delay.



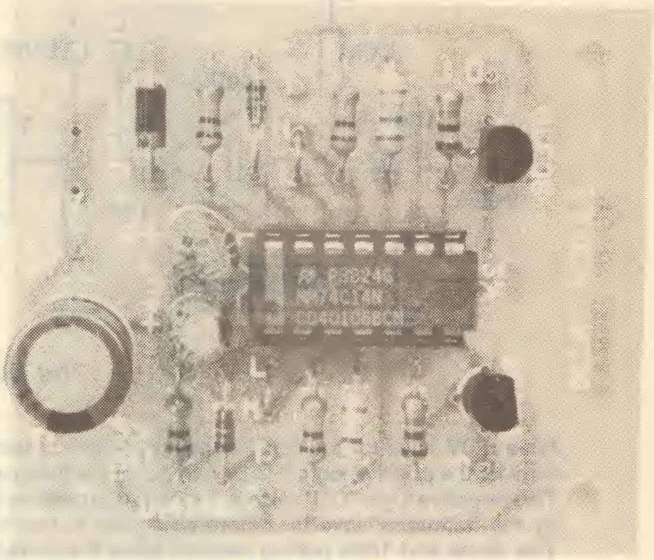
This diagram shows how to wire the Delay Module for use with the DMS. As is shown, you can connect the input of one delay to the output of the other to cascade them.

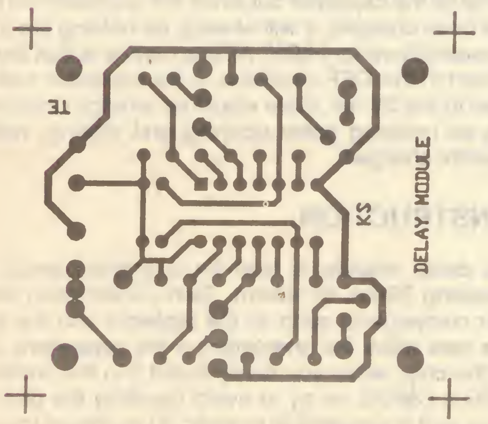
PARTS LIST

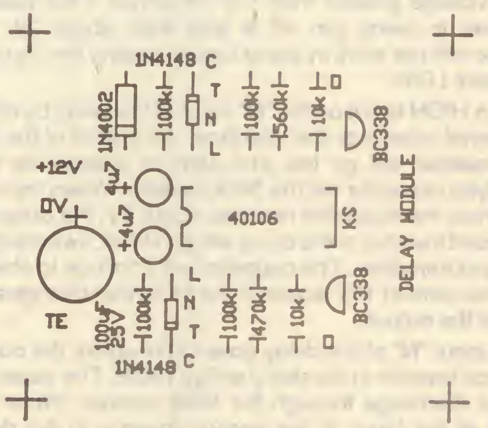
2- 10k
4- 100k
1- 560k
1- 470k

2- 4u7 16V electro
1- 100uF 25V electro

1- 1N4002
2- 1N4148
2- BC338 Transistors
1- 40106 Hex Schmitt Inverter
1- 14 pin IC Socket
1- **DELAY MODULE PCB**



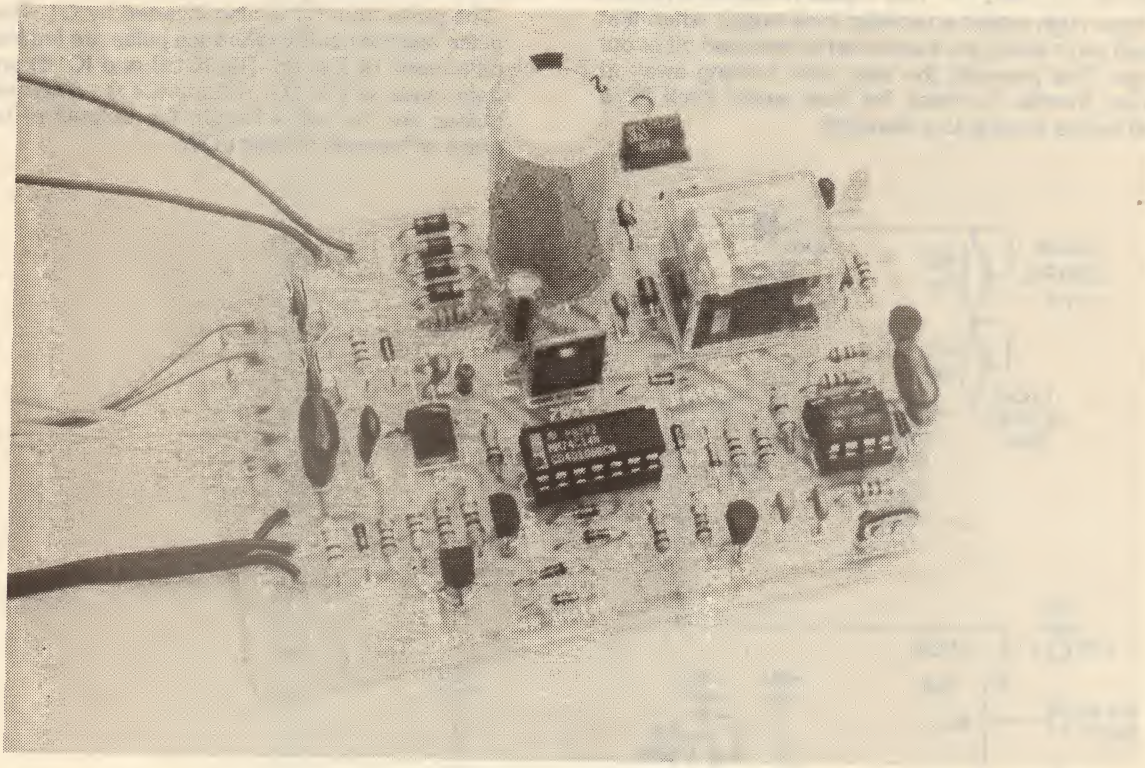




The printed circuit artwork for the Delay Module.

WALK-AROUND THROTTLE

Tired of being tethered to your layout? Perhaps you'd like to watch your trains from a different vantage point. Gain some freedom of movement with this radio controlled throttle.



On large layouts, walk-around throttles are popular because they allow the driver to stay with his train, monitoring its progress better than he could from some remote location. Walk-around throttles vary a lot in design from simple throttles that must be plugged into the layout at various locations, right through to real "wireless" control systems where the driver is totally unrestricted in his movement.

While the simple plug in arrangement is cheap and does work, it has some disadvantages. The obvious one is being tethered to the layout. Another is unless you have a throttle specially designed for the purpose, the train will stop every time you unplug the controller.

Wireless type controllers overcome these problems, allowing full control of the train from any location on the layout. There are two systems that can be employed; infra-red or radio. This article describes how to adapt a commercial radio control set to use as a walk around throttle.

The radio link is provided by the radio control unit. The circuit described here is a throttle that is compatible with the pulse system used by the radio gear, and is actually an adaptation of a successful MOSFET electronic speed controller that has been used in radio controlled buggy racing. Note that these buggies are not the cheap affairs that can be picked up at a supermarket, but rather specialist racing machines that are usually priced at over $500.

Don't let that price scare you. Now that the radio controlled buggy fad is dying, second-hand two channel radio sets can be picked up quite cheaply. Often they are for sale with worn out buggies. The unit in the photographs cost me only $20, including a buggy that had been chewed by the owner's pet Alsatian. The radio gear was fine.

I have bought a few sets of second-hand radio gear. The only problems I have found with them is that sometimes the servo that was used for steering has been damaged. This project doesn't use the servos anyway. Just don't buy a unit that has been used in a boat. If the receiver looks as if it has been wet, there is a good chance that it will be corroded inside. This applies to the receivers from buggies too!

I should point out here that this unit is designed for R/C gear that uses the positive pulse system. Most of the common brands do. I have used this throttle with Futaba, Kraft, Techniplus and JR radios. Don't try to use it with the radio control set out of a child's toy buggy. You'll never get it to work.

ABOUT THE CIRCUIT

The radio controlled throttle is made up of several smaller blocks, each quite easy to understand.

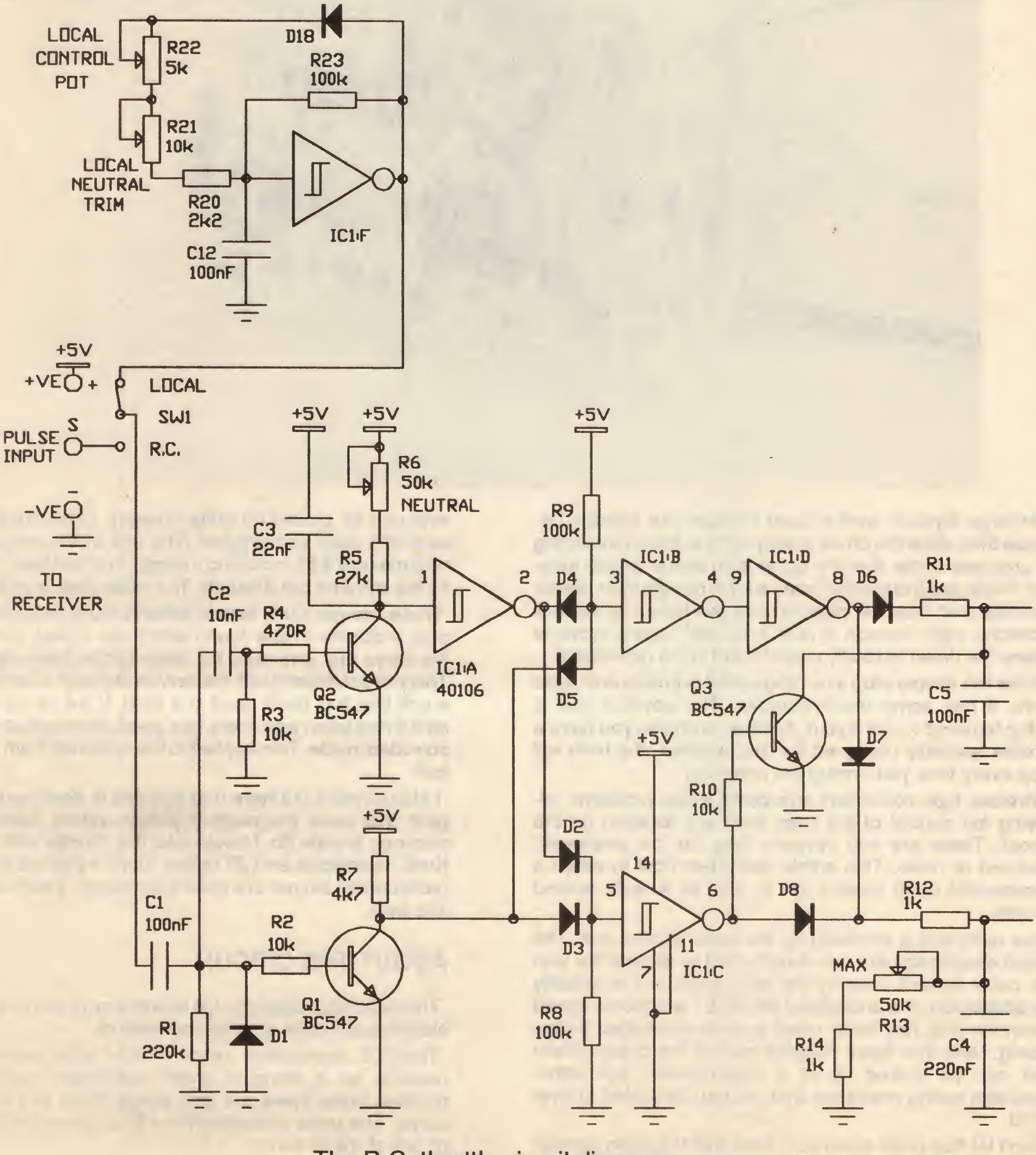
The R.C. transmitter sends control information to the receiver as a string of width modulated pulses. The receiver sorts these out and sends them to the correct servo. The radio controlled throttle is connected in place of one of these servos.

The throttle runs off 12V AC. The AC is rectified and smoothed by D14-17 and C8. R19 and C9 provide decoupling for the control circuitry. VR1 and its associated components, C10 and C12 provide regulated 5 volts for the radio control receiver and the throttle's pulse processing circuits. The receiver is designed to run on five or six volts, so the regulator is essential.

The decoded pulse train from the receiver is fed to the throttle via SW1 and C1. This capacitor blocks any constant logic High signal a receiver may output when first switched on or when the transmitter is switched off or out of range. This prevents the train from running away at maximum throttle. At most, the train would lurch for a second before coming to a standstill.

Under normal circumstances C1 will pass the pulse train through to R2 and C2. C2 puts a very short spike on the base of Q2, which turns it on briefly, charging C3. C3 then discharges through R5 and R6. This pulse is cleaned up and inverted by IC1:A to give a positive going pulse. This pulse is adjusted by trimpot R6 so it is the same length as the pulse from the receiver when the transmitter stick or knob is in the neutral position. This pulse is the neutral reference pulse.

The pulse from C1 is also inverted by Q1. The inverted pulse and the neutral reference pulse are fed into an AND gate made of D4, D5, R9, IC1:B and IC1:D and a NOR gate made of D2, D3, R8 and IC1:C. When both of the pulses are the same length, the outputs of both these gates will remain at logic LOW.

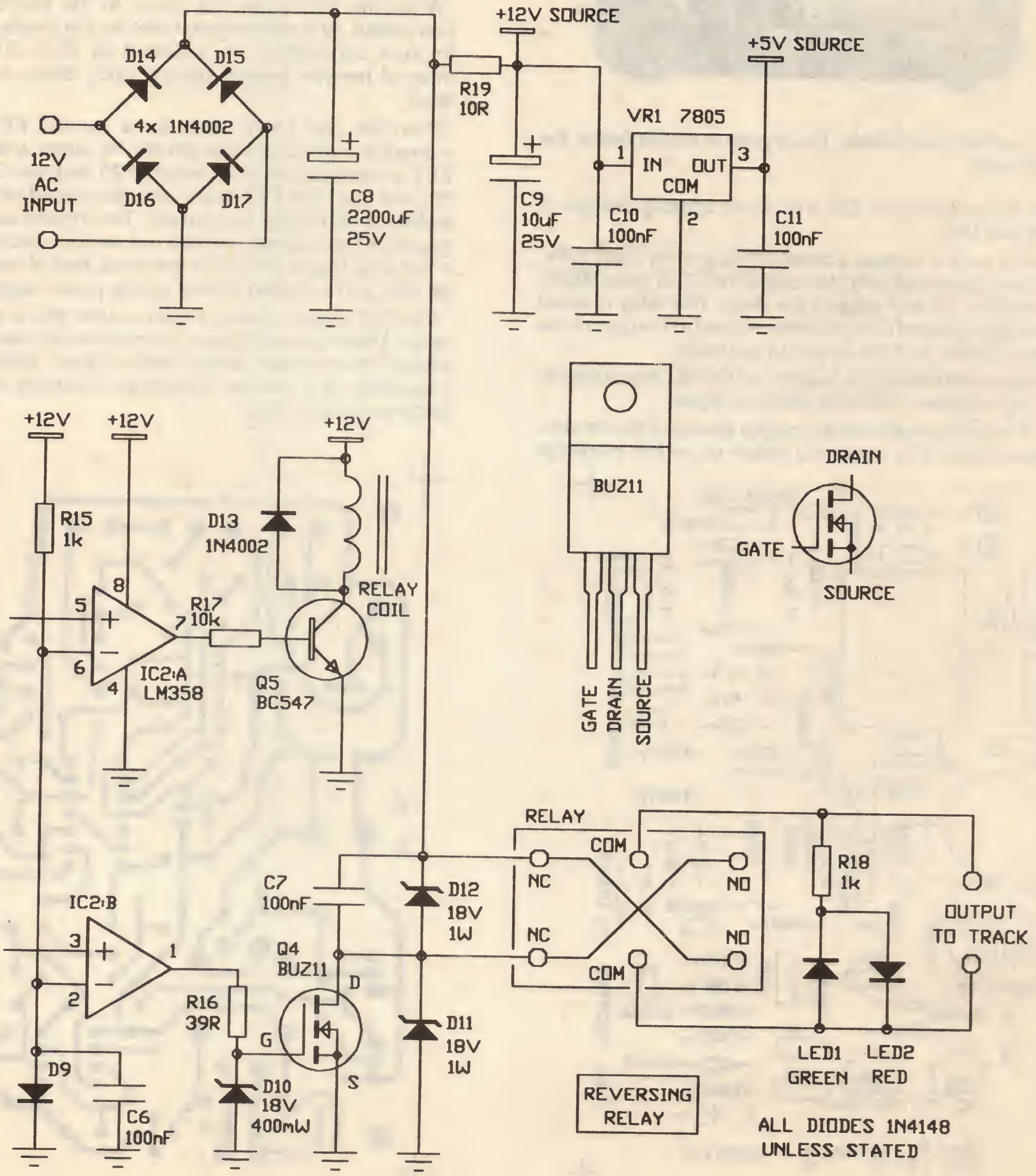


The R.C. throttle circuit diagram.

When the pulse from the receiver becomes longer than the neutral reference pulse, a narrow pulse, equal to the difference in the pulse lengths, is passed through to D8 and R10. This turns on Q3 briefly ensuring that C5 is discharged. (more on this later) and charges up C4 via R12. The pulse will vary in length according to the position of the transmitter stick or throttle knob and thus represent the speed required. Depending on the length, C4 will be charged different amounts. It then discharges more slowly through R13 and R14. The resultant ramp is fed to half of IC2, which is wired as a comparator. The 0.6 volt reference voltage being fed to the inverting input of the comparator is generated by D9, R15 and C6.

When the voltage across C4 is greater than 0.6 volts the output of the comparator will be high. R13 is adjusted so that at full throttle on the transmitter stick or throttle knob, the voltage across C4 does not fall below 0.6V, thus giving a constant HIGH out of the comparator. The output of the comparator is hence a variable mark/space ratio, continuously variable between 0 and 100%. This pulse train, with appropriate buffering, makes an ideal PWM (Pulse Width Modulation) speed controller.

The corresponding reverse circuit functions in the much the same manner except for a couple of minor differences. The first is that the AND gate passes the difference in pulse length when the incoming pulse is shorter than the neutral pulse. The pulse is passed through to R12 and C4 via D7. This gives the same 0 to 100% PWM control as described above. The second difference is that instead of discharg-



The modified transmitter. The crystal is visible below the control knob.

ing C5 by switching on Q3, the circuit actually charges it via D6 and R11.

As soon as the voltage across C5 is greater than 0.6V, (which is almost instantly) the output of IC2:A goes HIGH, switching on Q5 and closing the relay. The relay is wired as a reversing switch and is between the FET output of the PWM controller and the output to the track.

As there is no discharge resistor on C5, Q3 is required to discharge it when forward is selected again.

A FET has been used as the output device of the throttle. It requires very little current to switch on as it is a voltage driven device. This makes it easy to connect directly to the comparator. To switch on a FET a voltage of 4 to 20 volts must be applied to the gate with reference to the source. The higher the voltage the more current the FET can switch. A voltage over 20 volts will destroy the FET.

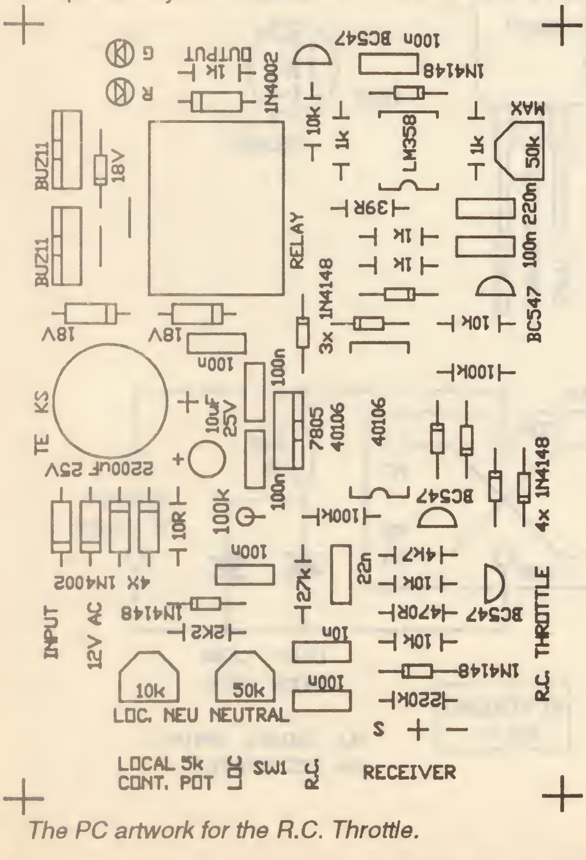
You will notice that IC2 is powered from the 12 volt rail. This is so that the FET can be turned on hard. If a 5 volt signal was used, the FET would not be turned on very hard, or in some cases, it would not be turned on at all.

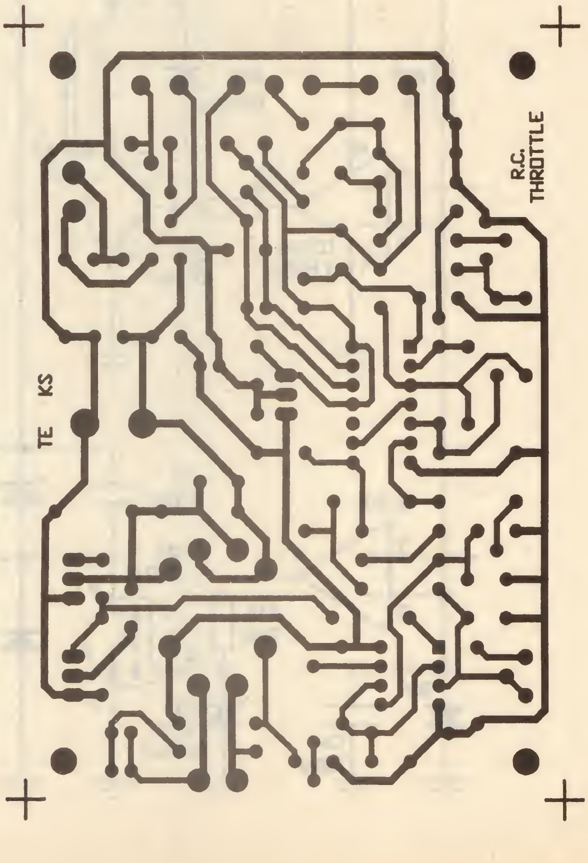
The output of the PWM comparator is fed to the gate of the FET via R16. There is an 18V zener across the source/gate junction of the FET. This zener limits the voltage fed to the gate of the FET to 18 volts and also snubs any spikes over 18 volts that may be induced on the gate via the internal capacitive coupling of the gate with the load current path inside the FET itself.

When the FET is on, the circuit to the train's motor is completed. Any spikes generated by the motor, or wheel to track connection are snubbed by D12, C7 and the internal reverse biased integral body diode in the FET itself.

Provision has been made for a second FET, should someone wish to use the throttle for larger scales. Each FET is rated at around 35 amps at 25 degrees C. Don't let this fool you. The FET leads, and the printed circuit tracks would never handle the current. The throttle as shown is good for 1 to 2 amps. I would not recommend more than a five amp load if two FETs are used. And of course if you do this, you will need to beef up the power supply.

The FET's worst enemy in a circuit like this is the voltage spike. Make sure all of your locomotives still have their TVI capacitors in place across their motors. Adding 100nF capacitors at a couple of strategic locations around the track would also help.





The PC artwork for the R.C. Throttle.

The circuit has no overload protection. I have tested the unit into a short circuit with no problems. However I would recommend using a 50W car headlamp bulb in series with the output of the throttle. The headlamp bulbs are still the best short circuit protection that anyone has come up with for model railways. Just remember that the lamp itself is an overload, so switch off the throttle as soon as you can, then go look for your short circuit.

The final section of the circuit to look at is the local control. SW1 switches between the pulse train from the receiver and the pulse train generated by this oscillator. This oscillator effectively emulates the pulse train of the radio control system, allowing the throttle to be used from a fixed position should it be necessary.

If you are not using the transmitter, switch it off. Transmitters are capable of inducing pulse trains in other circuits. They can cause control problems if taken too close to other circuitry, and can introduce an audible noise in amplifiers.

Remember that you are on a shared radio band. There are numerous crystals available, giving you a range of channels to choose from, but if someone else is using your channel, show some consideration. You will be close enough to you receiver to swamp their signal, but in doing so, you may interfere with the control of their model, and this leads to buggies driving down drains, planes dropping from the sky and so on.

CONSTRUCTION

The speed controller is constructed on a printed circuit board measuring 101mm by 70mm. The overlay on the PCB shows component location and orientation. The orientation of the FETs are represented by a line through the symbol on the side that the metal surface or tab should face. Zeners are represented by their zener voltage.

Install the two links first. Next install all of the low profile components such as the sockets, the resistors and diodes, followed by the taller components. IC1 and the FET are static sensitive devices and should be handled with care. Make sure that your soldering iron is properly earthed to prevent any static build up on it. It is also a good idea to earth yourself when handling the FET, but if this is impractical, at least touch something that is earthed to discharge any static before handling it.

Solder the rainbow cable that runs to the receiver next. The brown or black wire goes to the small pad marked "-". The red wire goes to the pad marked "+" next to it. The orange or other coloured wire goes to the other end of the PCB to the pad marked "S". The plugs used on the receivers vary from brand to brand, as does the order in which these wires are. Plugs can be bought as spare parts usually with a length of cable included, but they can be very expensive. The plug could be cut from a servo but doing so will disable servo. Alternately, a small 3 pin 0.1 inch spaced socket can be used in most cases, one of the exceptions being the old Futaba plug.

On all the radio systems mentioned earlier, the red wire is positive, the black or brown wire is negative, and the other wire, be it white, blue or orange, is the signal wire. If you are unsure, open the receiver and trace the wires from the receiver's battery to the PCB.

A heatsink will help keep the FET cool. I mounted my FET from the underside of the PCB so I could bolt it to the aluminium sheet on which I mounted my throttle. Use an insulating kit if you do this.

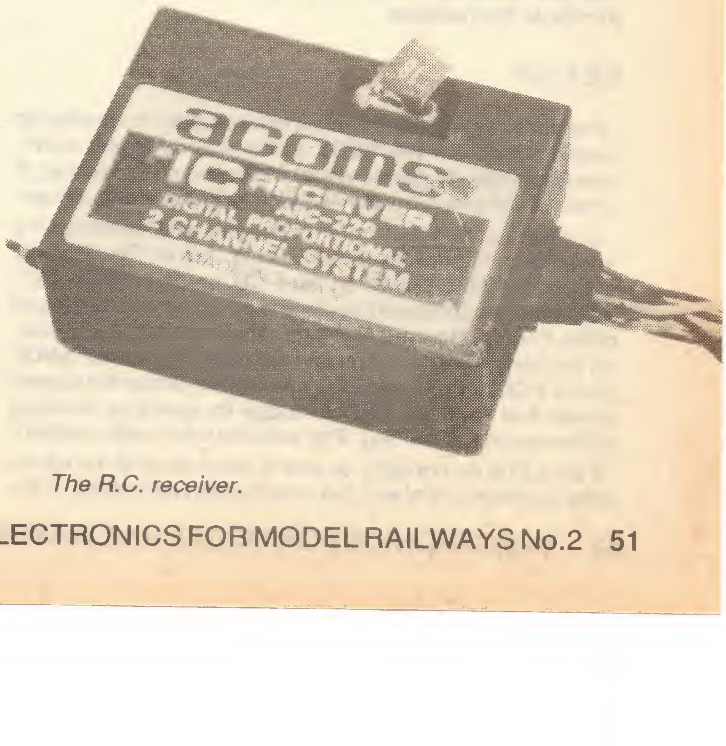
I replaced one of the joy-sticks on my transmitter with a pot, as I felt it was more convenient than the joy-stick. It is

PARTS LIST

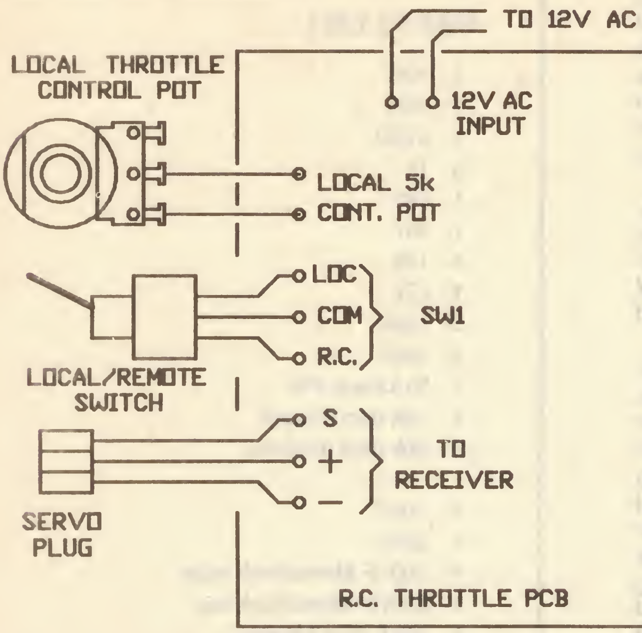
1- 10R
1- 39R
1- 470R
5- 1k
1- 2k2
1- 4k7
4- 10k
1- 27k
3- 100k
1- 220k
1- 5k Linear Pot
1- 10k mini trimpot
2- 50k mini trimpots

1- 10nF
1- 22nF
7- 100nF Monoblock caps
1- 220nF Monoblock cap
1- 10uF 25V Electro
1- 2200uF 25V Electro

1- 18V 400mW Zener
2- 18V 1W Zeners
10- 1N4148
5- 1N4002
4- BC547 Transistors
1- BUZ11 FET
1- 7805 regulator
1- LM358 Dual Op-Amp
1- 40106 Hex Schmitt Inverter
1- Green 3mm LED
1- Red 3mm LED
1- 12V DPDT RELAY
1- 14 pin IC socket
1- 8 pin IC socket
1- SPDT Toggle Switch
1- R.C. THROTTLE PCB



The R.C. receiver.



This diagram shows how to wire the R.C. Throttle.

not simply a matter of using a pot the same value as the one in the joy-stick because joy-sticks use only 90 degrees of the pot's travel. The joy-stick must be removed from the transmitter and the pot's travel measured with a multimeter. I found mine to use about 1k of travel on a 5k pot. It was offset from one end by about 1k9. So I used a 1k pot with a 1k8 resistor on one end of it and a 2k2 on the other. It all adds up to 5k and the transmitter worked fine. The joy stick on my transmitter was easily removed by undoing four screws. Unfortunately, more often than not, the joy-sticks are integral with the case, so it requires some creative hacking to adapt the case to take a pot.

If you prefer, it is a simple matter to remove the spring return from the back of the joy-stick. This will stop the stick centring as soon as you release it. A small friction pad can be arranged to stiffen the joy-stick if required. Some transmitters actually have provision for this on the back of the joy-stick.

If you wish to use two throttles with one receiver, that is one per channel, leave out 5 volt wire from the second throttle to the receiver.

SET UP

In order to set up the throttle it is necessary to monitor its output. There are two LEDs on the printed circuit board, near the relay, to give a visual indication of the output. A small 12 volt electric motor will also help in the adjustment.

Connect the throttle to your radio gear and switch on the transmitter. Centre the throttle knob. Adjust R6, which is marked by "NEUTRAL" on the PCB, so that neither LED is illuminated. Connect the electric motor across the output of the throttle. Now move the throttle knob on the transmitter to about 7/8ths of travel and adjust R13 (marked "MAX" on the PCB) until the motor is running just under the fastest speed that it will go. You can judge its speed by listening to the sound it is making. This sets the full throttle position.

If the LEDs do not light, or one of them stays lit the whole time, go back and check the construction and wiring. If the Neutral pot has an effect, but you are not able to get the LEDs to go out, increase the value of R5 to 47k. This will only be necessary if the transmitter pulses are exceptionally long. Alternately if they are exceptionally short, reduce the value of R5 to about 10k. If the maximum speed setting is a problem, increase R14 to 10k or 22k.

Now that you have the throttle adjusted to the transmitter, switch SW1 across to the "LOCAL" position. With the local throttle knob centred, adjust the "Local Neutral" trimpot (R21) until both LEDs are off.

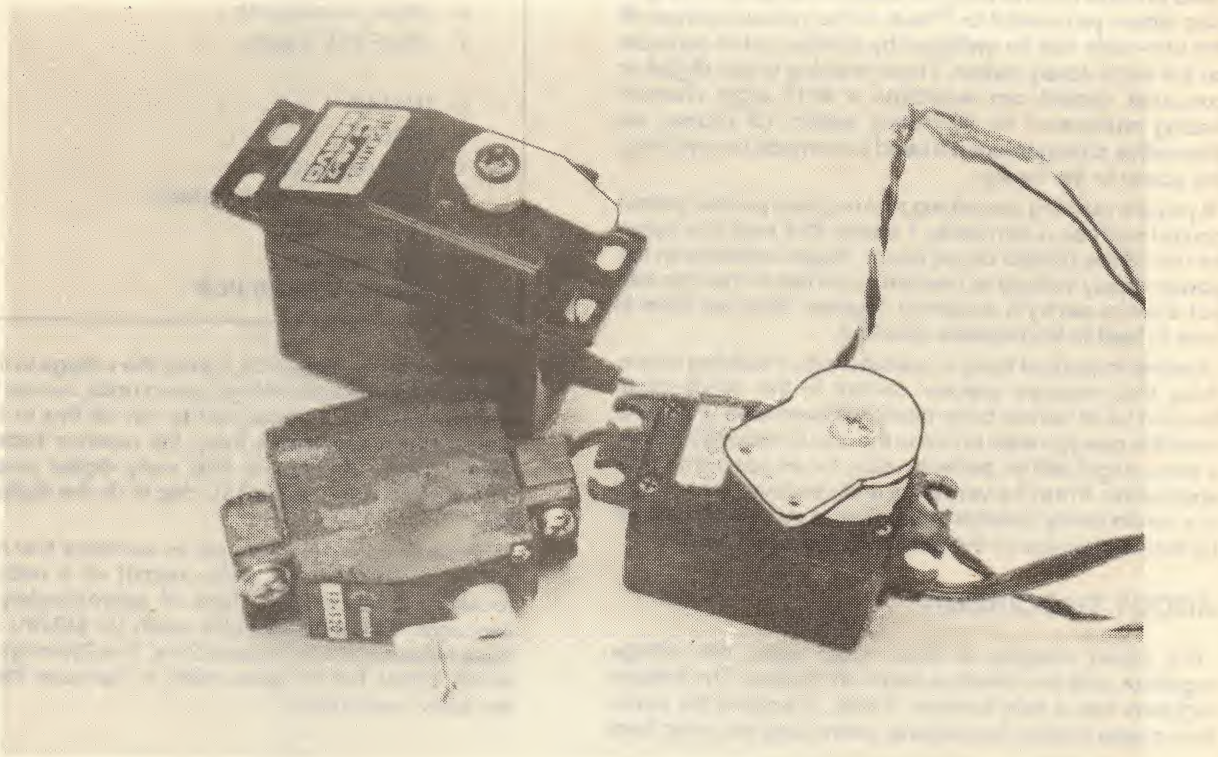
This completes the set up of the throttle.

Now where is Kimi's toy car?

Remember that you are sharing the R.C. band with other people.

SERVO DRIVER

Add some animation to your models! This simple circuit will enable you use the servos from Radio Control Sets as accurate accessory drives for your layout.



Three digital proportional servos, each from a different manufacturer. Each uses its own type of plug and wiring. Apart from this, they are interchangeable, as they all work with the positive pulse system.

So you've made the radio controlled throttle and now you have two servos lying around depreciating. If only you could use them for something...

Well now you can. This very simple circuit emulates a radio control system, providing an adjustable pulse suitable for driving servos. There are two similar circuits on the printed circuit board, each capable of driving a servo.

Now, what are you going to do with them? I can think of numerous possibilities, and will outline them here. A set of boom gates, or the older style crossing gates can be driven. As they contain a motor and reduction gearbox, servos are a lot slower than a solenoid. Because of this they will close the gates quite realistically. Another advantage is that the limits of the servo's travel can be simply adjusted using the trimpots provided on the printed circuit board. This means you won't have to spend hours trying to bend an obstinate piece of brass wire to get the gate to open to the right height, only to find that you have mucked up the closed position in doing so.

The printed circuit board has been arranged so that a switch can be used to select several adjustable preset positions. In this case, only two would be needed, one for open and one for closed. A single pole double throw (SPDT) toggle switch could be used to do the job, or a circuit could be arranged to do it automatically. The Crossing Boom Control described in Electronics for Model Railways Book 1 can be easily modified to do the job. Simply leave out the motor control circuit and use the contacts on the relay to switch between a pair of trimpots on the servo driver printed circuit board.

If full sized potentiometers are used instead of the trim pots, you can have direct and precise control over the servo's almost infinite number of positions. One use for such a setup springs to mind instantly. With two or three servos, a very precise operating crane could be made for loading and unloading your trains. This alone would make a club running day more fun. Goods are so often ignored due to the complexity and high price of commercial cranes.

Alternately, you could use the servo to drive a wagon tipper of the sort that is used to empty wagons into waiting ships.

A simple turn-table could even be made to operate from a servo. The obvious limitation in this case is the load which would be put on the servo. Unless you purchase an expensive "monster" servo, or put a great deal of effort into making the turn-table very free in its operation, you will most likely be limited to narrow gauge and N gauge. Another limitation with a servo is that it cannot turn a full 360 degrees. It is limited to roughly 270 degrees. This will

allow a locomotive to be turned, but a little "shunting" may be required to get it facing the right way on a particular track.

The printed circuit board has provision for eight trimpots, making it easy to wire a rotary switch to the board to give eight preset positions. Aligning the turn-table with the tracks is simply a matter of adjusting the appropriate trim pot until the track and turn-table are aligned. You won't need to muck around with limit switches to get the thing to stop where you want it to. Power to the various sidings off the turn-table can be switched by another set of contacts on the same rotary switch. Those wishing to use digital or computer control can substitute a 4015 eight channel analog multiplexer for the rotary switch. Of course, an alternative arrangement will need to be made for switching the power to the tracks.

If you are building something that requires precise preset control such as a turn-table, I advise that only one servo be run off the printed circuit board. Slight variations in the power supply voltage or internal cross talk in the chip can put a servo out by a couple of degrees. Such an error is sure to lead to locomotives derailing.

Another important thing to consider when building something that requires precise control is the servo itself. Second hand servos have often had hard lives. It pays to hook the one you wish to use to the circuit and test it. While a servo might still be perfectly okay for an open/shut type application, it may be very jerky and non linear when used in a continuously variable mode. This is most likely caused by dust or damage to the pot inside the servo itself.

ABOUT THE CIRCUIT

The circuit consists of three major parts, the voltage regulator, and two identical servo controllers. The voltage regulator has a twin function. Firstly, it isolates the servo from power supply fluctuations, preventing it moving from preset positions. Secondly, it limits the voltage to five volts. Except for some special high speed units, servos for radio control systems are designed to run off five to six volts. One of the reasons is to keep the receiver battery pack weight down. Another is that early digital proportional receivers actually used a TTL chip to do the digital decoding.

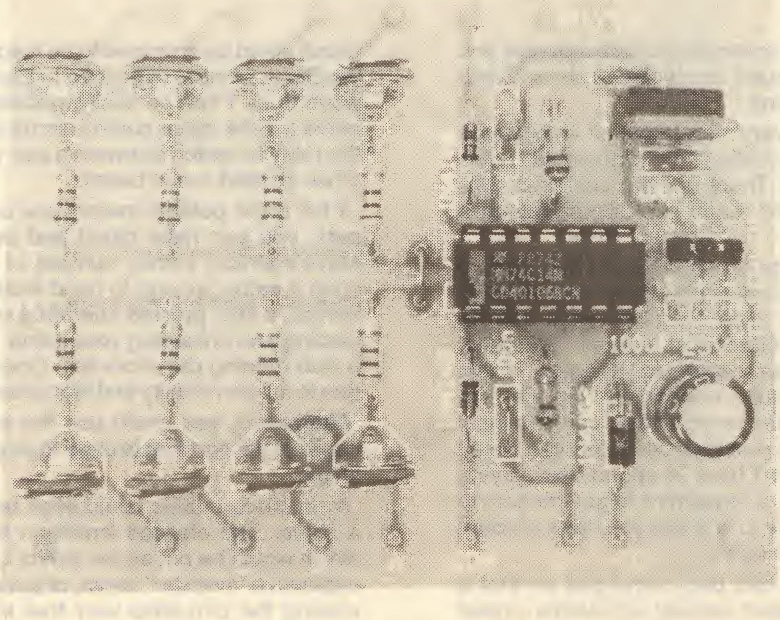
The servo controller is simply an oscillator that has been set up to emulate the pulse output of a radio control receiver. It has a cycle time of approximately 20 milliseconds. The positive pulse width (or MARK) is adjustable between about 1ms and 2ms. The 20ms cycle length is not critical, but the pulse width is, because this is what the servo responds to.

PARTS LIST

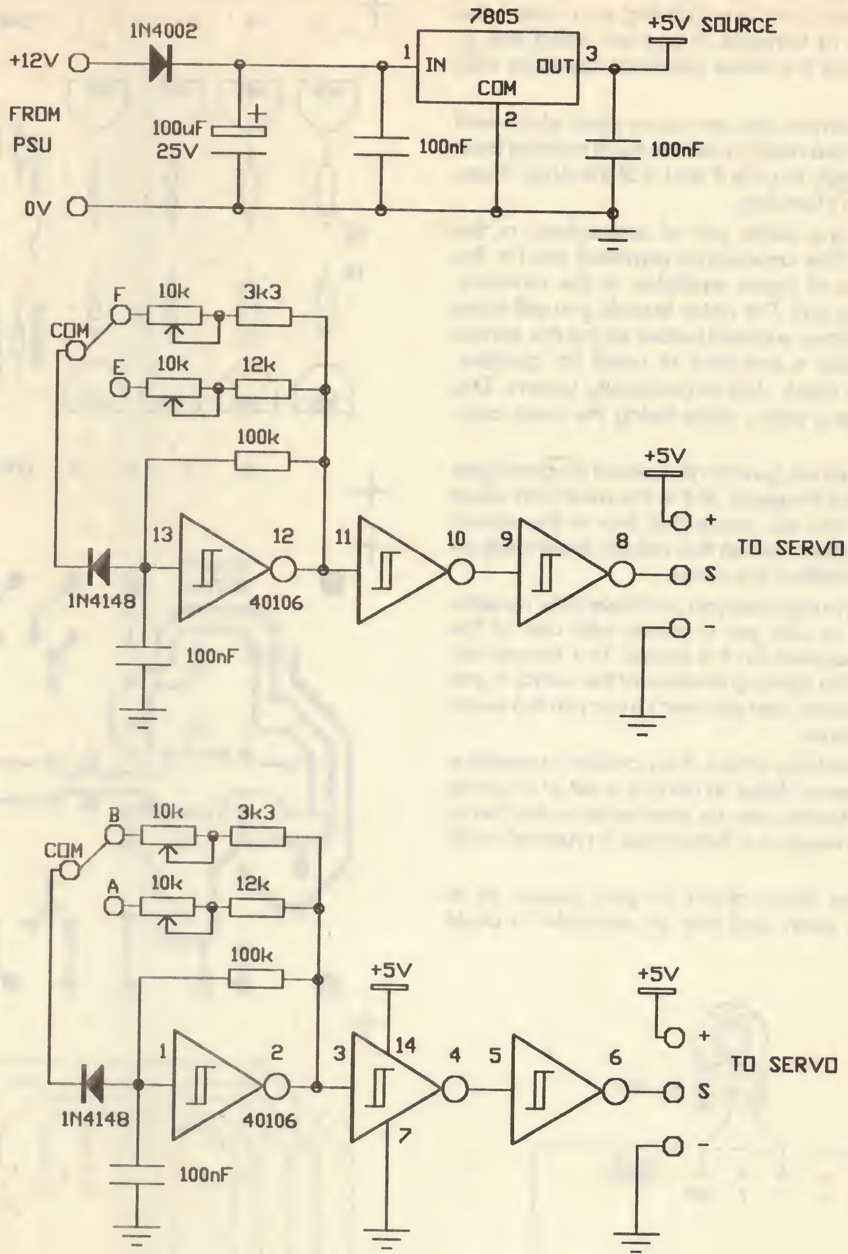
6- 3k3
2- 12k
2- 100k
8- 10k mini trimpots

4- 100nF monoblocks
1- 100uF 25V Electro

2- 1N4148
1- 1N4002
1- 7805 regulator
1- 40106 Hex Schmitt Inverter
1- 14 pin IC socket
2- 3 pin headers
1- **SERVO DRIVER PCB**



The 8 position version of the servo driver. Note the two links.



The Servo Driver circuit diagram.

The servo contains a monostable multivibrator. Its pulse width is adjusted by the pot that is connected to the servo's output shaft. The servo adjusts the pot so that its internal pulse width is the same length as the one that is being sent to it by the receiver, or in this case the oscillator. So by adjusting the pulse width we feed to the servo, we can control the position to which the servo will move.

The prototype servo controller used a National Semiconductor 74C14/CD40106B chip. If you use another brand, you may find that the timing becomes incorrect. If so, the value of the resistors or capacitors may need to be changed.

When you are adjusting the unit, or if you are using it with a pot, make sure that you do not let the servo try to run past its end. If you send a pulse that is either too wide or too narrow, the servo will try to match it but will run out of pot travel. As it will be physically impossible for the servo to turn any further, it will sit there with D.C. applied to its stalled motor, eventually damaging something. How do you know when a servo is at the end of its travel? Listen to it. If the servo is making any noise while it is stationary, it is either jammed or overloaded.

CONSTRUCTION

The Servo Driver is built on a printed circuit board measuring 78mm by 63mm. All components except for the switches are mounted on the board. No heatsink is required for the regulator.

Start construction with the lower components such as the resistors and the socket. Take care with the orientation of the capacitors, diodes, regulator and the chip, when you finally insert it in the socket.

Decide which version you are building and install the appropriate number of trimpots. If you are using five or more trimpots, replace the lower oscillator capacitor with a link.

Also place a link between the two spare pads at the end of the chip. You will also need to cut the track running from the lower of these pads to pins 2 and 3 of the chip. If you don't, the circuit won't function.

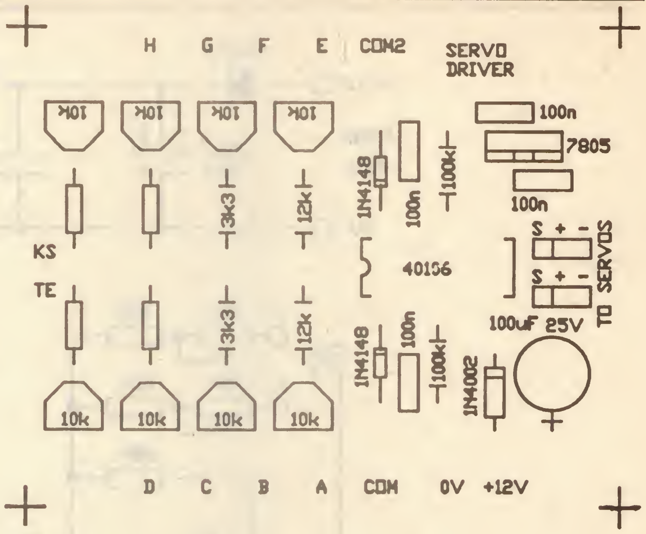
Not all servos use the same sort of connectors, or the same wiring order. The connectors provided are for the most common types of servo available at the moment, including Acoms and J.R. For other brands you will need to check the connections yourself before wiring the servos to the board. Usually a red wire is used for positive. Negative is usually black, but occasionally brown. The signal wire can be any color, white being the most common.

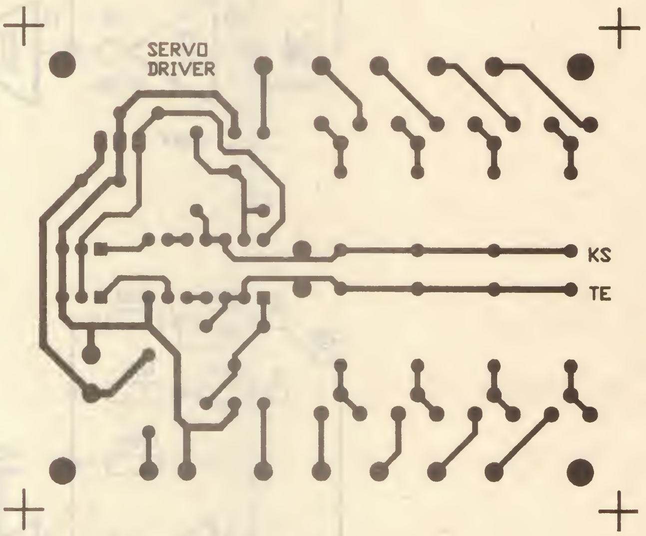
The fixed resistor values given in the circuit diagram give different offsets to the trimpots. 3k3 is the minimum value that may be used. You will notice that four of the values have not been specified. Select the values depending on where you wish to position the servo.

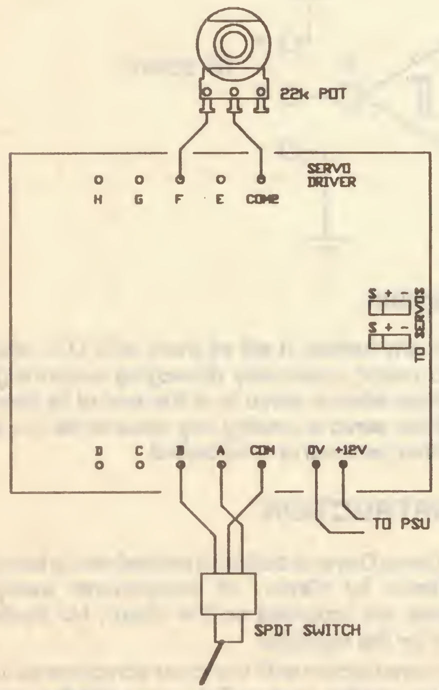
If you wish to use a pot so that you can have fully variable control, wire a 10k or 22k pot in series with one of the trimpots and 3k3 resistors on the board. The trimpot will allow you to preset the starting position of the servo. If you use a 22k pot, be careful that you don't try to run the servo past the end of its travel.

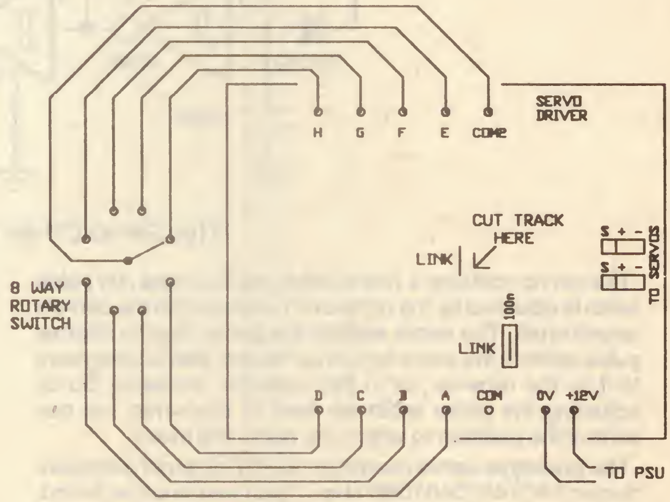
As mentioned in the delay article, it is possible to combine the delay and the servo driver to control a set of crossing gates. The Delay Module can be interfaced to the Servo Driver using either relays or a 4052 triple 2 channel multiplexer.

When installing the Servo driver on your layout, try to keep the wires as short and tidy as possible to avoid interference.





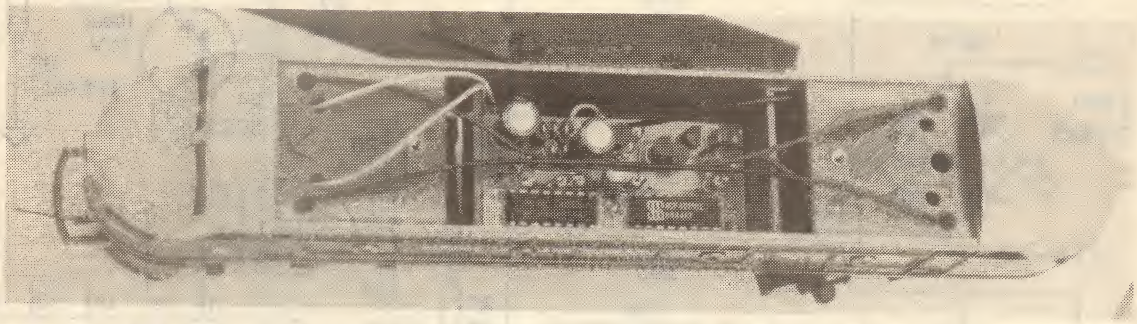




The three ways in which the servo driver can be wired. The diagram to the left shows the wiring for a two position setup and a fully variable one. The diagram to the right is for an eight position application, such as a turntable.

DIESEL SOUND

Imagine having a long goods train hauled around your layout by a beautifully detailed diesel locomotive that sounded like the real thing. No longer do you have to tolerate the tinny whine of the electric motor that is the real source of the locomotive's power, because here is a project that generates a convincing diesel engine sound.



The tiny Diesel Sound Generator easily fits into this OO scale locomotive. The battery is in the space over the non powered bogie, while the speaker is below the PCB, in a small plastic compartment, facing downwards.

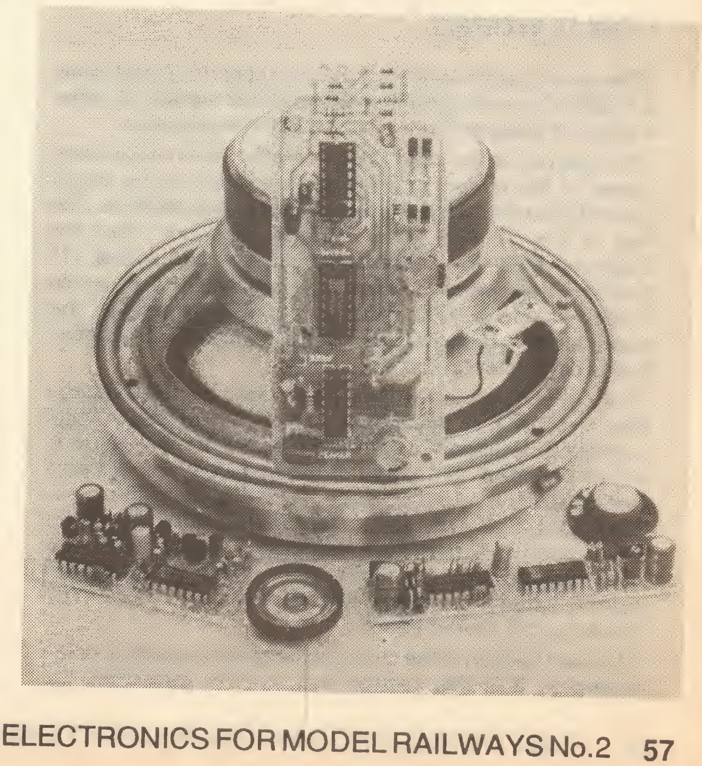
Way back in 1980, I became immensely interested in sound effects and music. As I was only a student at the time, a synthesizer was beyond my financial reach until my father came to the rescue at Christmas. But before that, I had to make do with what I could afford with my dollar a week allowance. So armed with a handful of chips bought for twenty five cents each, when a local "electronics" shop decided to clear its range of CMOS, I sat down at my desk and started work on my well used piece of proto-board.

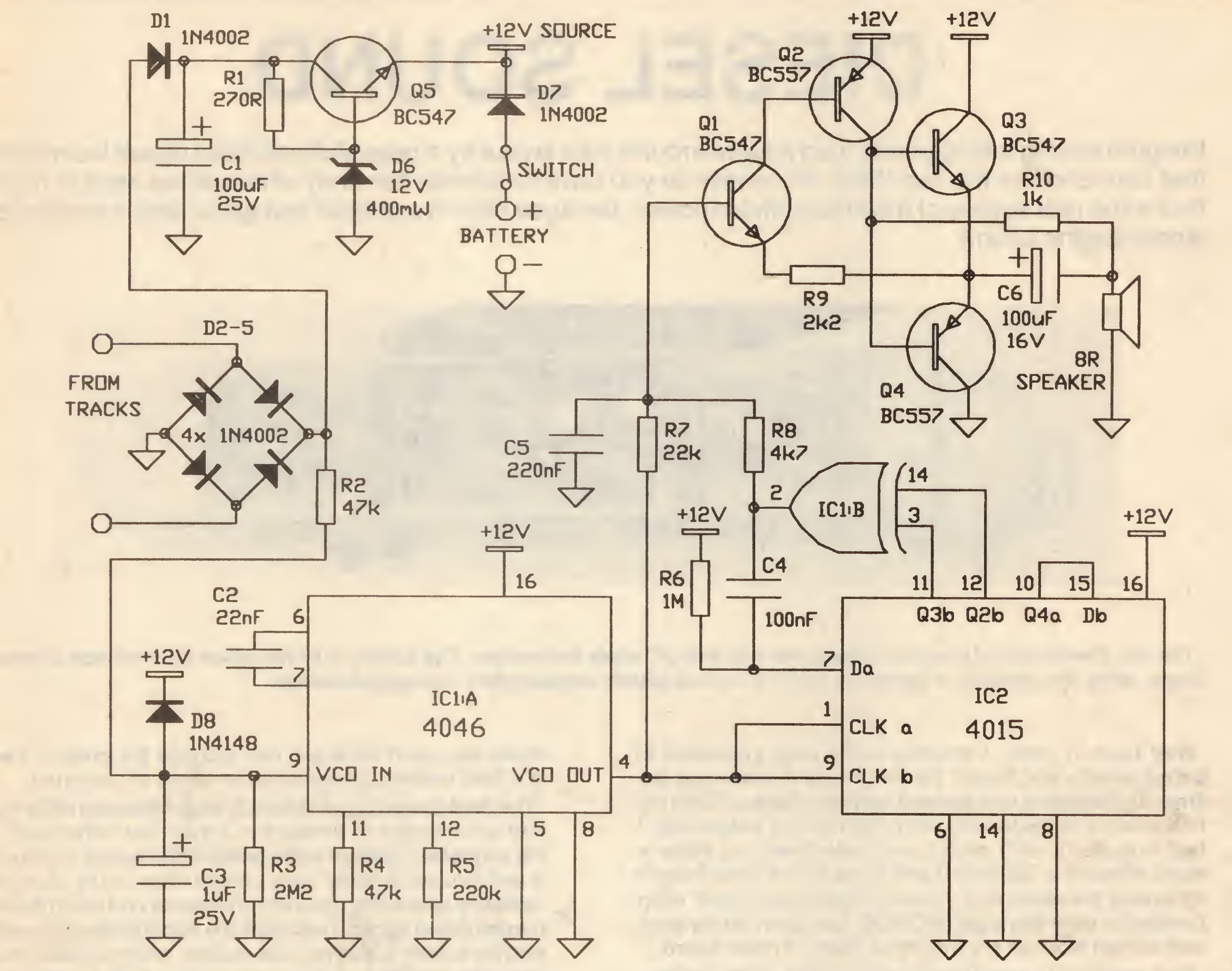
The creation I assembled used a 4021 shift register, about three 4046 VCOs and some exclusive-OR gates, either a 4070 or the ones integral to the 4046. It was basically a digital pseudo-random noise generator. What does this have to do with model railways I hear you ask. This rats-nest produced the best range of sound effects I have ever heard from something so cheap, including convincing steam and diesel engine effects. As I wasn't all that keen on model railways at the time, the potential of this circuit never occurred to me. Many years later I saw a similar, though simpler circuit as a design idea in a model railway magazine. That started me thinking again. The following project is the result.

There are three versions of the diesel sound generator so the one most suited to your needs can be selected. Two of them are small enough to be coaxed into HO and OO engines, or vans and box cars, helped by different shaped PCB designs to allow for different space limitations. One of them is long and thin, and should fit into the narrower bodies used on some diesels. The other is for fitting into wider but shorter spaces.

Both of these printed circuit boards are very compact and use a lot of very thin tracks. These tracks are susceptible to over or under etching and are very easy to damage while soldering. This makes them highly unsuitable for an inexperienced hobbyist to build. Good construction skills are essential, as are a fine tipped temperature controlled soldering iron and a pair of good quality side cutters. For those who don't think you can manage the project, there is a third version, designed to be easier to construct.

The third design is considerably larger than the other two, and is not meant to installed in a train, but rather back at the controller. I figured as there was little chance of coaxing a unit into an N scale loco, construction could be made easier by spreading the components out and using thicker printed circuit tracks. I also took the opportunity to do away with the battery the other units require, and to install a more powerful amplifier. I have run these diesel simulators through twelve inch speakers to great effect.





The circuit diagram of the on board Diesel Sound Generator. There are two different PCB designs, but the circuit is the same.

HOW IT WORKS

The circuit can be looked at as several parts. Some areas will differ depending on the version. First we will consider the circuit designed to be carried in the locomotive.

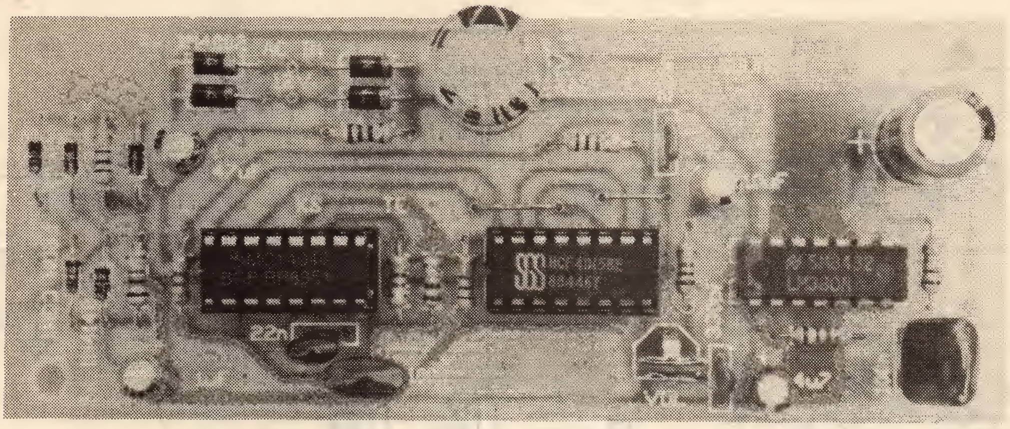
The first part is the input bridge rectifier. This makes sure power of the correct polarity is always fed to the diesel sound generator. It feeds power to two circuit sections. The first is the 12 volt zener voltage regulator. See the Economy PSU for a description of how this works. C1 smooths the output of pulse type throttles into a usable constant voltage. D1 prevents any voltage held in the capacitor from being fed back to the second circuit section that is connected to the input bridge.

The second section is the speed detector. The voltage from the track is fed to the control pin of the voltage controlled oscillator in the 4046. As the track voltage is varied to control the speed of the locomotive, it will also modulate the frequency of the VCO, changing the simulated diesel's revs. So the faster the train goes, the faster the engine will sound. As a real diesel engine contains a lot of rotating mass, the rate at which it can rev up or slow down is limited. C3 along with its discharge resistor R3, simulates this inertia effect.

The next section of the circuit is the pseudo-random noise generator. It is this section that actually generates the characteristic diesel throb. It consists of a seven stage shift register with its two last outputs Exclusive-ORed together and fed back into its input.

The square wave output of the VCO is used to clock the 4015 shift register. On each positive transition of the square wave, the data that is on pin 7 of the shift register is clocked into its first stage. At the same time the data in the first stage is clocked into its second stage, the data in the second stage is clocked into its third stage and so on. The data is eventually lost when it is clocked out of the eighth stage. The 4015 is really a dual 4 stage shift register with each stage having its own output pin. By feeding the last output of the first shift register into the data input of the second one, we have made an eight stage shift register. In this circuit, the outputs are taken from stages six and seven. The eighth stage is not used.

The Exclusive-OR gate compares outputs six and seven of the shift register, its output reflecting what is at the input pins. If either input is high, the output of the Exclusive-OR gate will also be high, but if neither or both inputs are high, the output will be low. This output is fed back into the shift register, and will soon be clocked through to outputs six and seven again. This results in an almost random stream of logic levels at the output of the Exclusive-Or gate. It is in fact a repeating cycle. Varying the number of stages in



The big one. Everybody will know when you fire this one up! I used an old car speaker with mine.

the shift register will vary the pattern. Seven stages seems to be the most suitable.

C4 and R6 are there to kick start the generator. It is possible that the shift register will start with all of its stages containing lows. And as a low compared with a low always gives a low, the pseudo-random sequence will never start. C4 and R6 hold the input high long enough for one or two highs to be clocked into the shift register. If your unit fails to start, reduce the value of R6.

The frequency of the VCO controls the rate at which the shift register is driven, thereby modifying the "throb" rate according to speed.

R7, R8 and C5 form a simple mixer and filter. The output of the pseudo-random noise generator is mixed with a little of the VCO's direct output and then the higher frequency component of the signal is shunted to the common rail via C5, while the remaining signal is amplified and sent to the speaker.

The VCO's direct output is used to simulate the whine of a supercharger. If you do not require the effect, leave out the 22k resistor R7.

The battery is there to provide power when there is not enough being picked up from the rails. D7 prevents the battery from being back fed. The switch is there so you can shut off the battery when you have finished running the train for the day.

If you cannot tolerate the thought of using a battery, replace C1 with a 1000uF electrolytic. The diesel sound generator will still work, but its performance will be adversely affected. It will no longer idle and slow speed performance will be poor, but you will never need to replace the battery!

The second version of the diesel sound generator differs primarily in two areas. The first is its power supply. It is fed from the rectified output of a transformer, and because of this requires no battery. Secondly, it uses an LM380 audio amplifier chip, giving a possible 4 watts out. With a decent speaker connected, your neighbours may think you are playing with a REAL diesel.

Some cunning modellers will be able to graft this unit directly onto the simple throttle presented in this book (before the reversing switch!), and do away with the need for both bridge rectifiers and a separate transformer. However, I recommend that a separate and isolated transformer winding be used to power each sound generator constructed. Usually, trying to run them off the same winding as each other or the throttle, or even other circuits from the book, is a recipe for disaster for the unwary. There are too many ways in which an unexpected connection can occur, and when one does happen, either a diode in one of the bridges, or the transformer winding itself, will be damaged.

CONSTRUCTION

Take out microscope and surgical tweezers... well nearly. As I said earlier, the two smaller boards are not suitable for beginners. (I will not repair botched attempts at these projects. They really are too delicate.) The first step is to select which board is more suited to your needs. Check the boards closely for any manufacturing errors such as shorts between tracks or track breakages caused by over etching. Clean up shorts with a sharp hobby knife and repair tracks by soldering single strands of wire taken from a length of flex. If you must do this, it is easier to wait until the components are all soldered to the board. Just don't forget if you leave it to later!

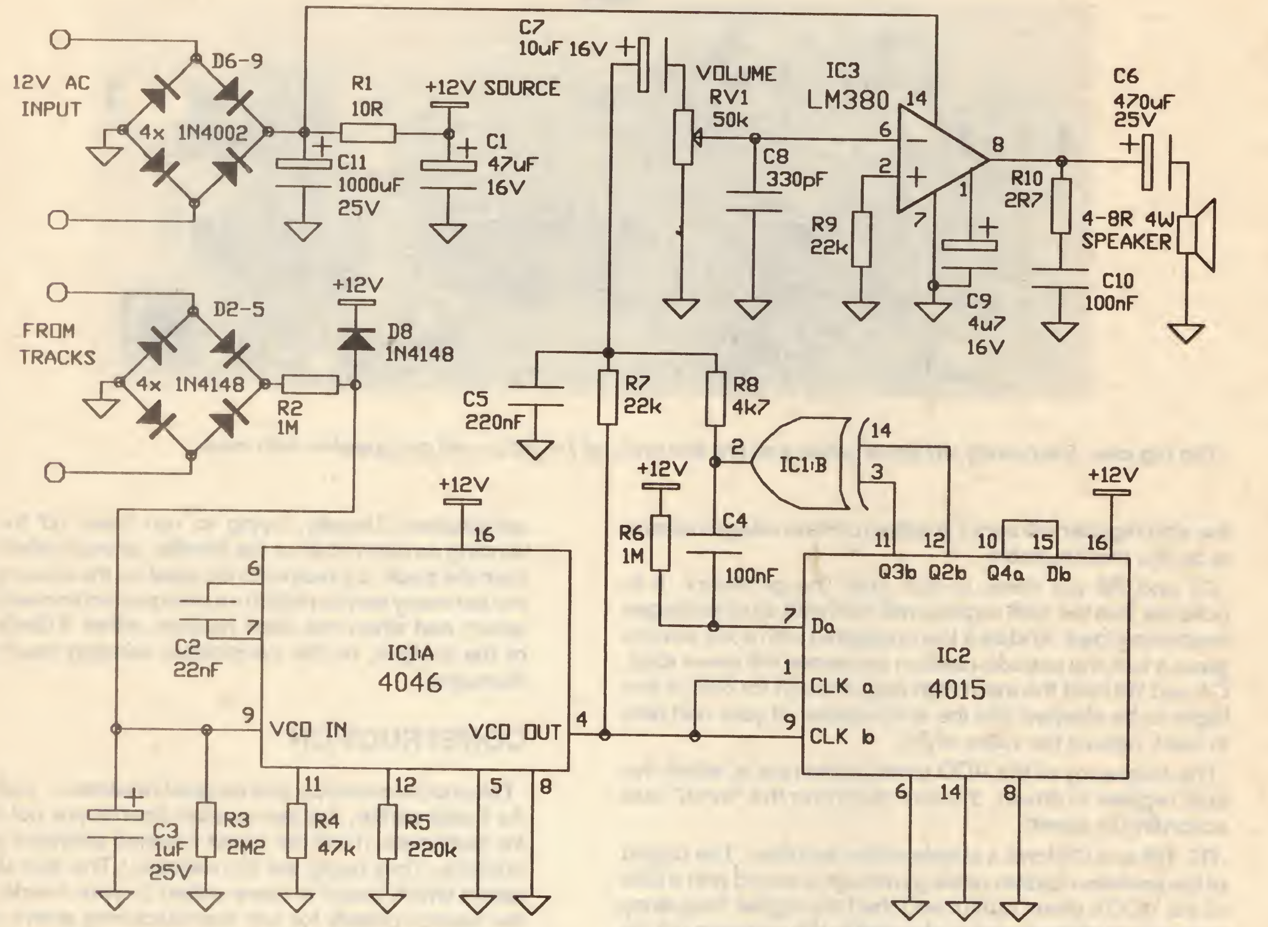
If you refer to the construction drawings you will see that there are several links. The shorter ones can be tinned copper wire. The longer ones will need to be insulated. On one version there is a link that is actually soldered between two resistors on the top side of the board.

The chips must be soldered directly to the board. Sockets take up too much space in a project this small. All resistors and diodes are stood on end to conserve space. The overlay on the board shows which end the body of the resistors should be placed. Refer to the photographs for the physical orientation of the diodes. Only their electrical orientation is on the overlay. The diode described as 12V is the 12 volt zener used in the regulator.

The capacitors should all be of the monolithic ceramic or monoblock type, once again to conserve space. Try to use small canned electrolytics too. The size of the 100uF capacitors varies a lot depending on manufacturer and age.

Do not substitute metal bodied transistors for the plastic ones recommended, or short circuits are sure to result.

The connections to the board have been put where they fit without taking up space. The connections to the diode bridge can be made by soldering either to the pads on the



The circuit diagram for the larger Diesel Sound Generator. While the amplifier and power supply circuits are different, the heart of the unit is the same.

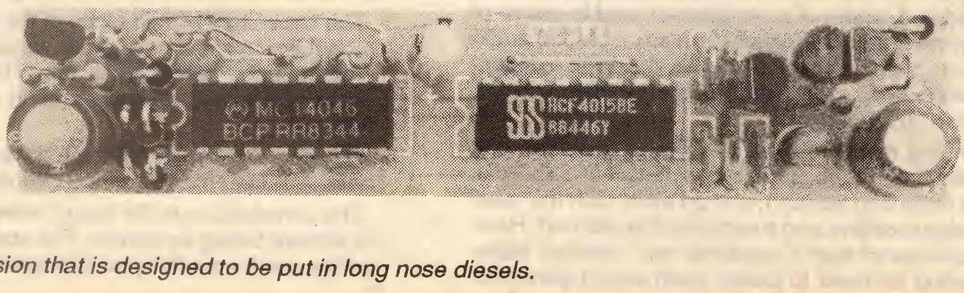
solder side of the board, or directly to the leads of the diodes.

The third version of the throttle should present no problems to any constructor, as it is neatly laid out with reasonable spaces between components. Do not use a socket for the LM380, as it uses the copper on the printed circuit board as a heatsink. The copper provided for the job is really not enough to dissipate the heat generated if the amplifier is run flat out for extended periods of time, but I doubt anyone will. Besides, the supply voltage is a little on the low side to allow full output power to be attained.

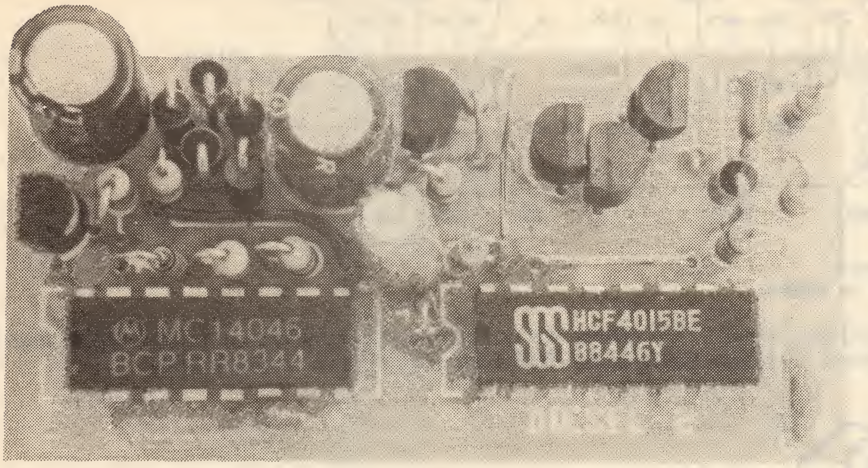
COMPATIBILITY WITH THROTTLES

The diesel sound generator responds differently to various types of throttles. I have tried it on all that were available to me at the time of writing. As it stands, it works well on the pulse type throttles presented in this book. I imagine it would work just as well on any other pulse type throttle. It is also completely compatible with variable voltage throttles like that presented in the last book of Electronics for Model Railways.

However, old current controlling throttles, that is any that use a rheostat to control speed, tend to make the diesel



The long thin version that is designed to be put in long nose diesels.



A close up of the shorter PCB. Note the physical orientation of the components, particularly the diodes.

sound generator over-rev. Some juggling with the input voltage divider would cure the problem, but I have found the simplest and most effective method to be reducing the battery voltage to six volts. The unit will be a little quieter at idle, but will otherwise behave normally.

FITTING THINGS INTO SMALL SPACES.

Obviously, if the diesel sound generator is to be built into a train, a small speaker is required. And obtaining suitable speakers has always been a problem too, until recently. Some companies have produced sound effect generating key-rings, equipped with a range of bizarre "revenge" effects, such as machine gun, death ray and grenade bomb! These gadgets are loud. Loud enough to be heard across a sizable warehouse over the background noise. Their secret is in their 27mm 8 ohm speaker. These speakers are only about 9.5mm deep, too, making them almost ideal. The good news is that these key-rings are cheap enough to buy just for the speaker alone. As for the sound generating module, hit it with a hammer, or toss it into the junk box, but whatever you do, don't wire it up to a big speaker and give it to your kid!

Finding a suitable battery can be a problem too. I have found that the diesel sound generator works best when run off a combination of power from the rails and an internal nine volt battery. Otherwise the sound effect stops when the locomotive does. If space is really tight, a row of button cells could be used, but as often as not, there is plenty of space. It is just that the space is usually of the wrong shape to put a standard nine volt battery into. The solution is to by an alkaline battery. The Duracell alkaline battery contains six very small pencil cells that can easily be separated and tucked into odd corners through the locomotive. Replacement will be infrequent too. There is one thing to be careful about when using these cells. While they look similar to "AA" cells their terminals are backwards. The negative terminal is the stud, while the plain flat end is positive.

PARTS LIST

On-board type

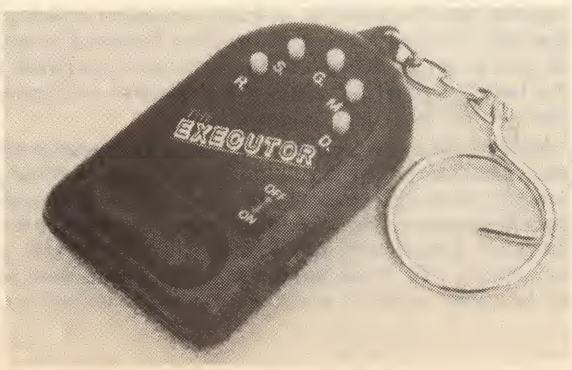
1- 270R
1- 1k
1- 2k2
1- 4k7
1- 22k
2- 47k
1- 220k
1- 1M
1- 2M2

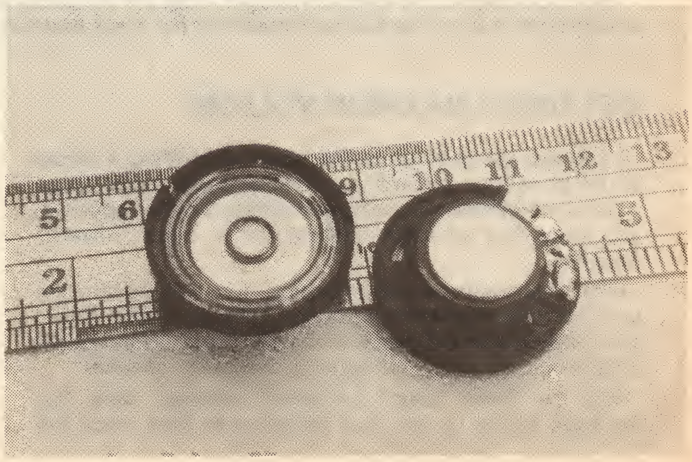
1- 22nF Monoblock
1- 100nF Monoblock
1- 220nF Monoblock
1- 1uF 16V Electro
2- 100uF 16V Electros

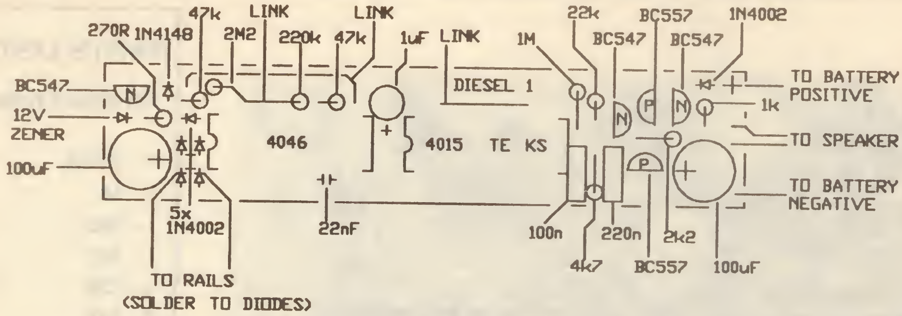
1- 1N4148
6- 1N4002
1- 12V 400mW Zener
1- 4015 Shift Register
1- 4046 VCO
3- BC547 Transistors
2- BC557 Transistors
1- Mini Switch
1- 9V Battery Snap
1- **DIESEL 1 or DIESEL 2 PCB**

EXTRAS:

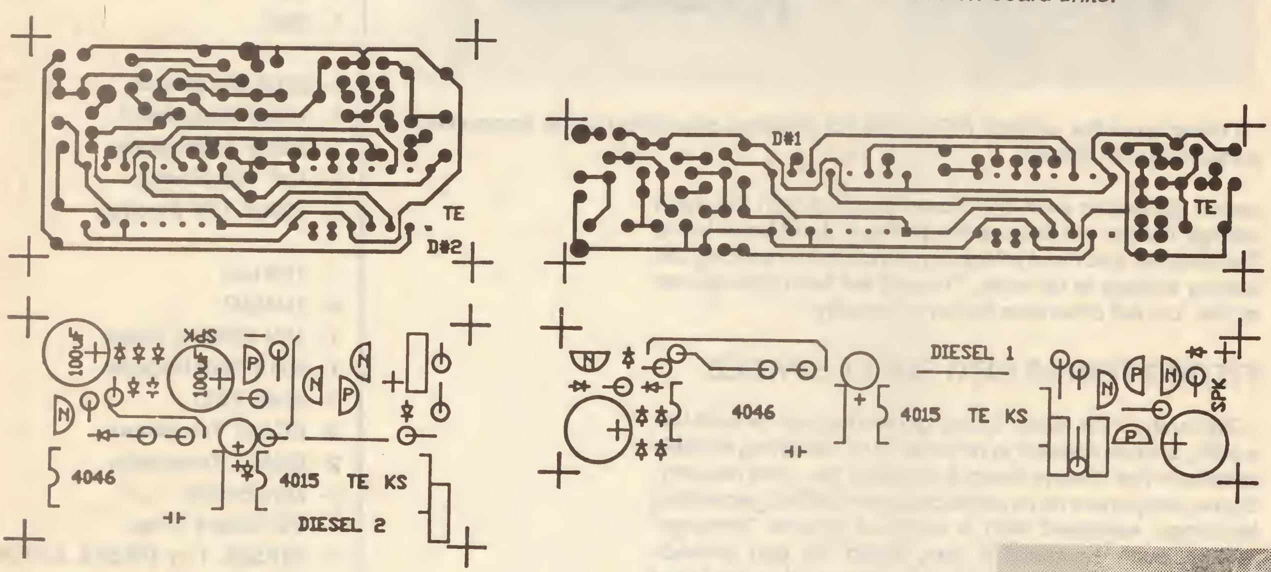
1- **EXECUTOR SPEAKER**

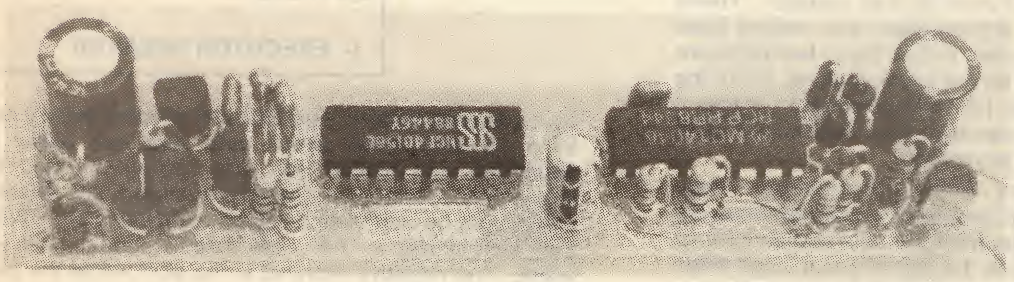






Refer to this diagram when assembling the Diesel 1 PCB. There are no component identifiers on the PCB other than the letters "N" for NPN, "P" for PNP, and the IC numbers. Below is the PCB artwork for the two on-board units.





The PCB viewed from a different angle. Note the link between the resistors on the right of the board. The smaller photograph shows were the connections are made for the wires that run to the locomotive's motor.

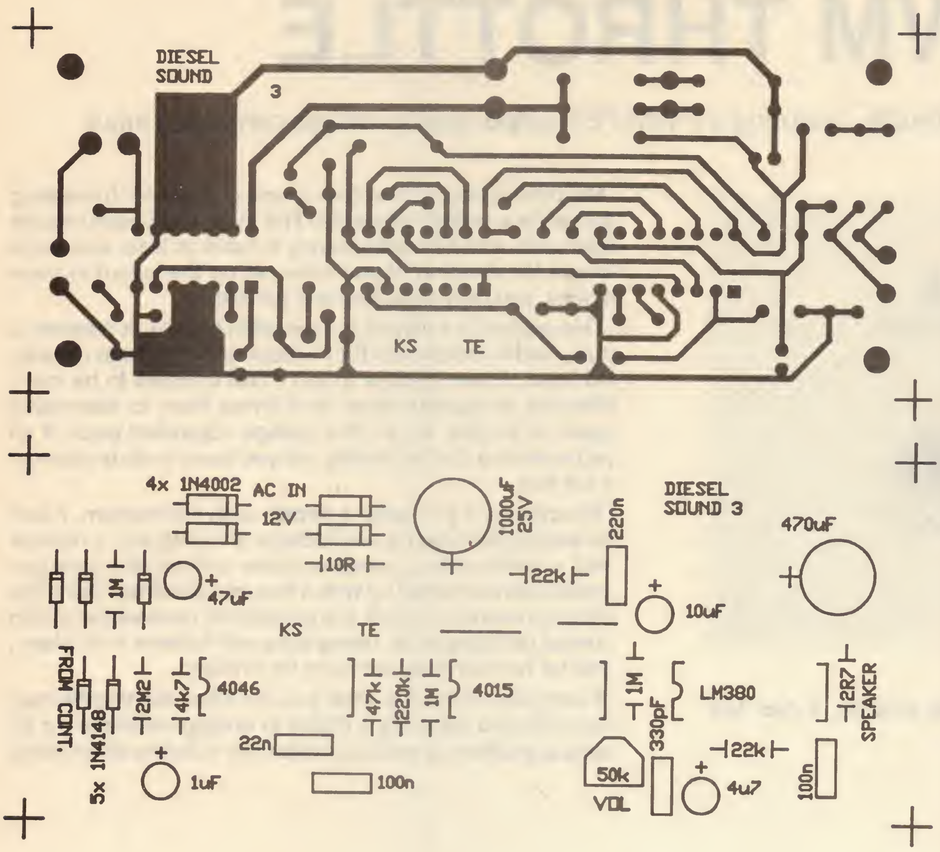
OBTAINING MAXIMUM VOLUME

If you are going to go to the effort of building a diesel sound generator, you will want it to be easily heard. Once you have built one up and have it driving that tiny speaker, you may find yourself wishing for a more powerful amplifier.

There is an alternate way to getting more volume from the unit. For demonstration purposes, take an empty 35mm film canister and cut a hole in the lid. The diameter of the hole should be nearly as large as that of the speaker.

With the diesel sound generator running, place the speaker, facing up, on your workbench. Now place the canister onto the speaker, so that the speaker is facing into the hole. You will notice a tremendous increase in volume as well as an increase in bass response. If you think that the bench is playing a part, lift the speaker and canister, and you will find it just as loud.

What you have just done is to provide the speaker with a resonant cavity, or simply put, a speaker box. I will not give any further details on how to arrange a suitable cavity in your locomotive. Undoubtedly, you won't find space for the canister! Experiment with building boxes to suit your locomotive from some plastic card. You may have to settle for less than optimum results due to space limitations.



The PCB artwork for the 4 Watt version of the Diesel Sound Generator. All component information is on the overlay.

PARTS LIST

4 Watt VERSION

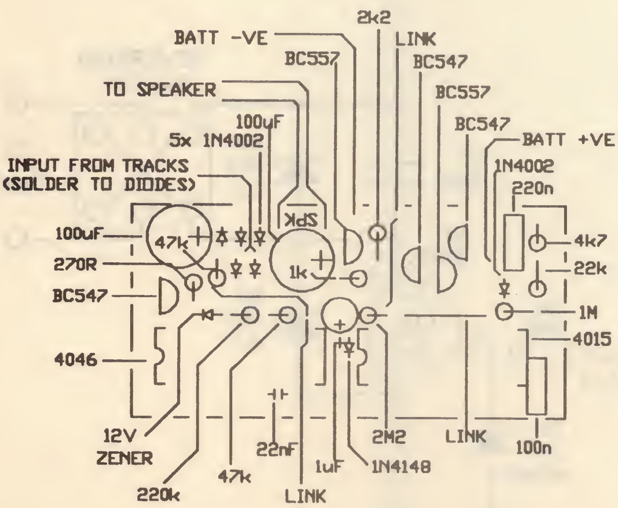
1- 2R7 or 2R2
1- 10R
1- 4k7
2- 22k
1- 47k
1- 220k
3- 1M
1- 2M2
1- 50k Mini Trimpot

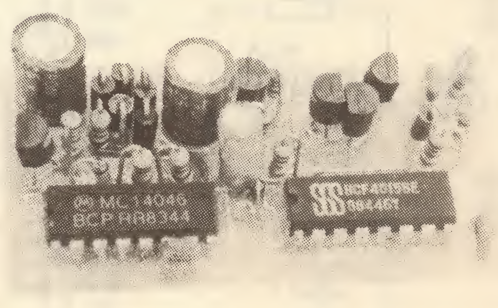
1- 330pF Ceramic
1- 22nF Greencap
2- 100nF Greencap
1- 220nF Monoblock
1- 1uF 25V Electro
1- 4u7 16V Electro
1- 10uF 16V Electro
1- 47uF 16V Electro
1- 470uF 16V Electro
1- 1000uF 25V Electro

4- 1N4002
5- 1N4148
1- 4015 Shift Register
1- 4046 VCO
1- LM380 Audio Amp IC
1- DIESEL SOUND 3 PCB

EXTRAS:

1- 4-8R 4 Watt Speaker

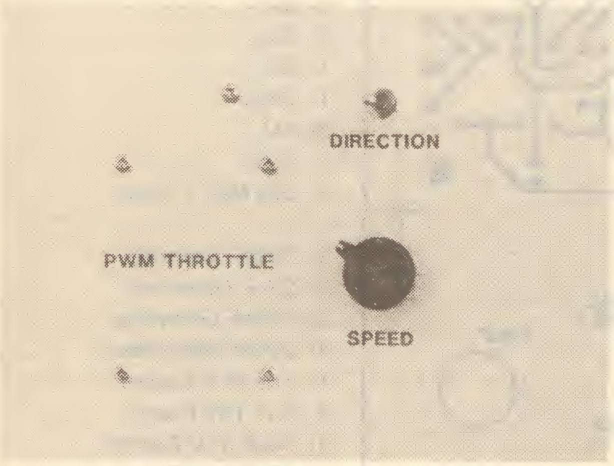




Refer to this diagram when assembling the Diesel 2 PCB. There are no component identifiers on the PCB other than the letters "N" for NPN, "P" for PNP, and the IC numbers.

PWM THROTTLE

A simple, high performance throttle, featuring a PWM FET output and a voltage controlled input.



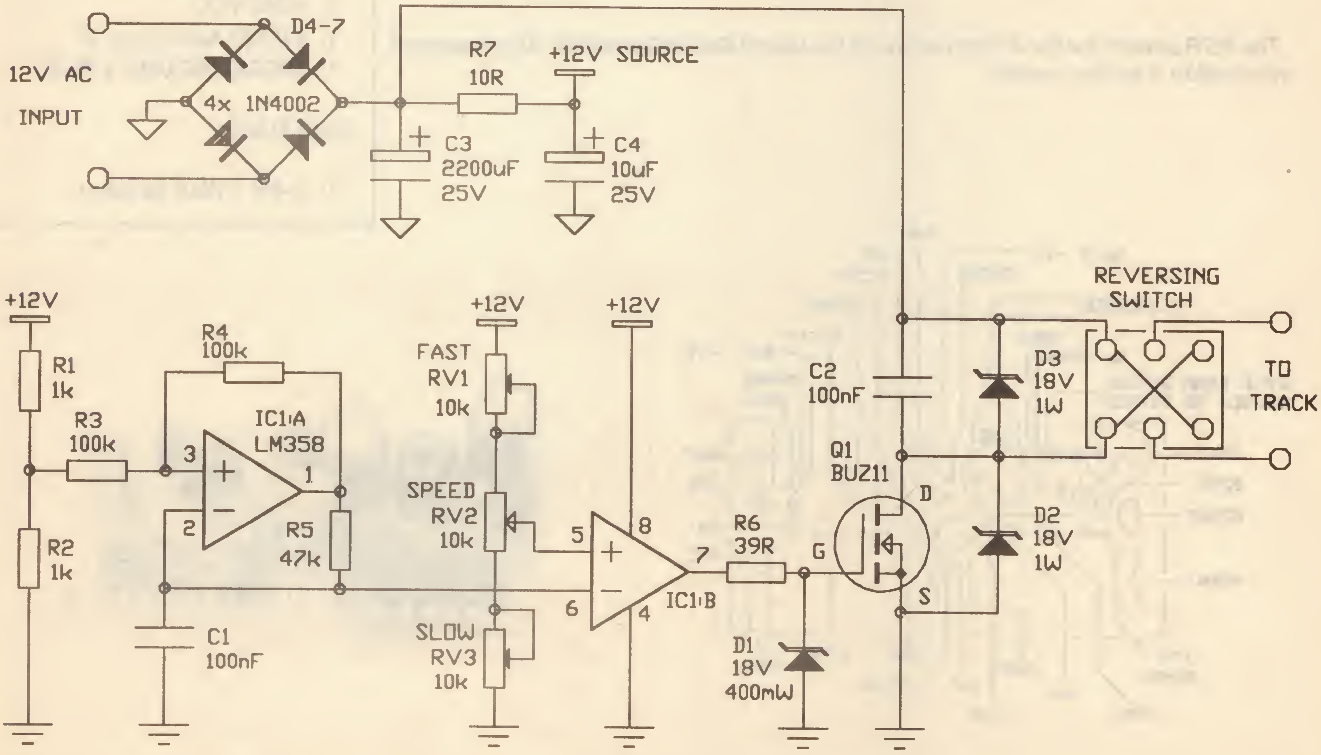
The simplest version of the PWM throttle. It has two controls: speed and direction.

Not having enough throttles is one of the most frustrating things for a railway modeller. The main lines each require their own, and it is really handy to have at least one more to use for shunting. If you have set up the layout to have blocks, you may even like one per block.

This project is a simple but versatile throttle. It features a pulse width modulated FET output and a voltage controlled input. I have always found PWM throttles to be more effective at starting trains, and prefer them to alternative types of throttle. As for the voltage controlled input, if all you want is a simple throttle, all you have to do is connect a pot to it.

Alternately, if you want a throttle with momentum, it can be easily achieved by the addition of an electro, a resistor and a switch. More complex brake and throttle arrangements can be lashed up with a few components. Using the basic momentum circuit, it is possible to remove the speed control pot altogether, using two push buttons in its place, one for accelerating, and one for braking.

If computer control is what you are after, the throttle may be controlled either by a digital to analog converter, or by selecting different voltage levels from a divider chain using



The PWM Throttle circuit diagram.

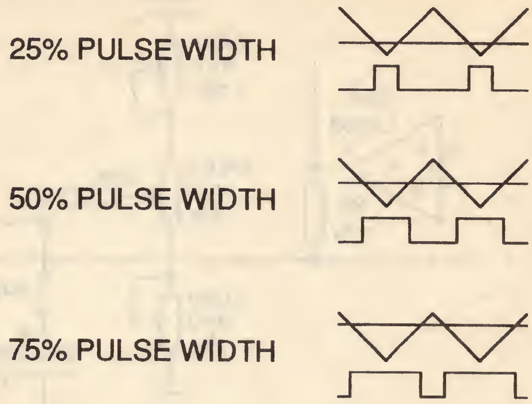
4051 analog multiplexer. In the second case, there will be only eight speeds available, but if the momentum circuit is used, it will smooth out the steps, making the transitions from one speed to the next undetectable. The reversing switch will need to be replaced by a relay. The Remote Relay Unit from Electronics for Model Railways No.1 is ideal. If you decide to go with the D/A converter, it is worth noting that an additive DC mixer will be required between the D/A converter and the throttle input, because the throttle input is offset by a few volts.

ABOUT THE CIRCUIT

IC1:A, an LM358 op-amp, is wired as an oscillator. Its function is very similar to that of an oscillator based 40106. Initially C1 will be uncharged, holding pin 2 (the inverting input) of the comparator at 0V. R1 and R2 form a voltage divider, generating a 6V reference that is fed via R3 to pin 3 (the non-inverting input) of the comparator. As the non-inverting input has a higher voltage on it than the inverting input, the output of the comparator will be HIGH (about 12V). This is where the second voltage divider, consisting of R3 and R4, comes into play. One end of R3 is connected to 6V. The output of the comparator is holding one end of R4 at 12V. Therefore the junction of R3 and R4, and pin 3 of the comparator, is at 9V.

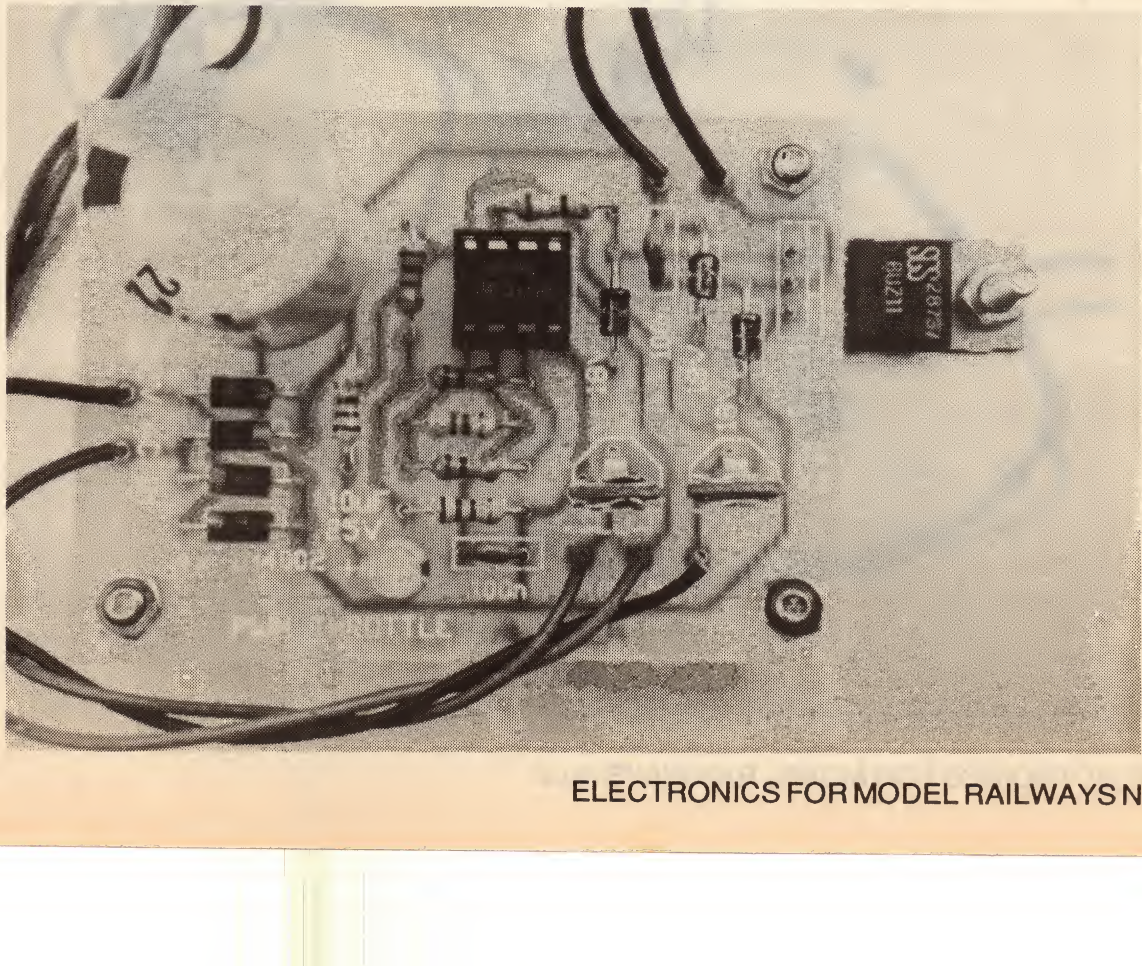
C1 is charged via R5 until the voltage across it reaches just over 9V. As the voltage on the inverting input of the comparator is now higher than its non-inverting input, the output will swing LOW, taking the end of the R3/R4 voltage divider with it. This means that pin 3 will now be held at 3V; halfway between 6V and 0V.

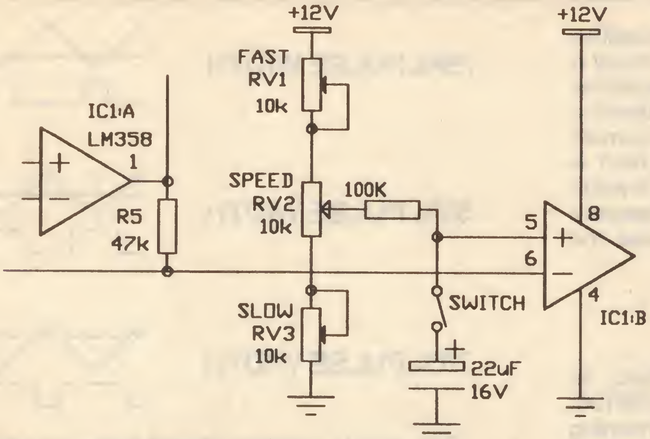
C1 will now discharge via R5 until the voltage across it is just under 3V. As the voltage on the non-inverting input is again higher than that on the inverting input, the output of the comparator will swing HIGH, staring the cycle over again.



This simple diagram should help you understand the principle of PWM. The three lines represent the inputs and output of the PWM comparator. The triangle wave is fed to the inverting input of the comparator. The straight line represents the control voltage that is fed to the non-inverting input of the comparator. Where it is with respect to the triangle wave determines what the output waveform will be. The rectangular wave shown for each case is the resulting output.

The voltage across C1 will therefore ramp up and down between about 3V and 9V. The waveform generated is very close to a triangle wave. This waveform is fed into pin 6, the inverting input of the second comparator IC1:B. Pin 5, the non-inverting input is the speed controlling input of the throttle. When the voltage at this pin is below 3V, the output (pin 7) of the comparator will be LOW, keeping the FET switched off. If the voltage is moved up to just over 3V, every time the voltage across C1 goes down to 3V, the comparator output will swing HIGH briefly, switching on the FET. If the voltage fed into pin 5 is moved up to 6V, the





The simple momentum modification.

duty cycle of the output will be at 50%. If the voltage is taken up above 9V, the output of the comparator will stay HIGH, keeping the FET switched on.

The output of the PWM comparator is fed to the gate of the FET via R6. There is an 18V zener across the source/gate junction of the FET. This zener limits the voltage fed to the gate of the FET to 18 volts and also snubs any spikes over 18 volts that may be induced on the gate via the internal capacitive coupling of the gate with the load current path inside the FET itself.

Any spikes generated by the motor, or wheel to track connection are snubbed by D2, D3, C2 and the internal reverse biased integral body diode in the FET itself.

The FET's worst enemy in a circuit like this is the voltage spike. Make sure all of your locomotives still have their TVI capacitors in place across their motors. Adding 100nF capacitors at a couple of strategic locations around the track would also help.

PARTS LIST

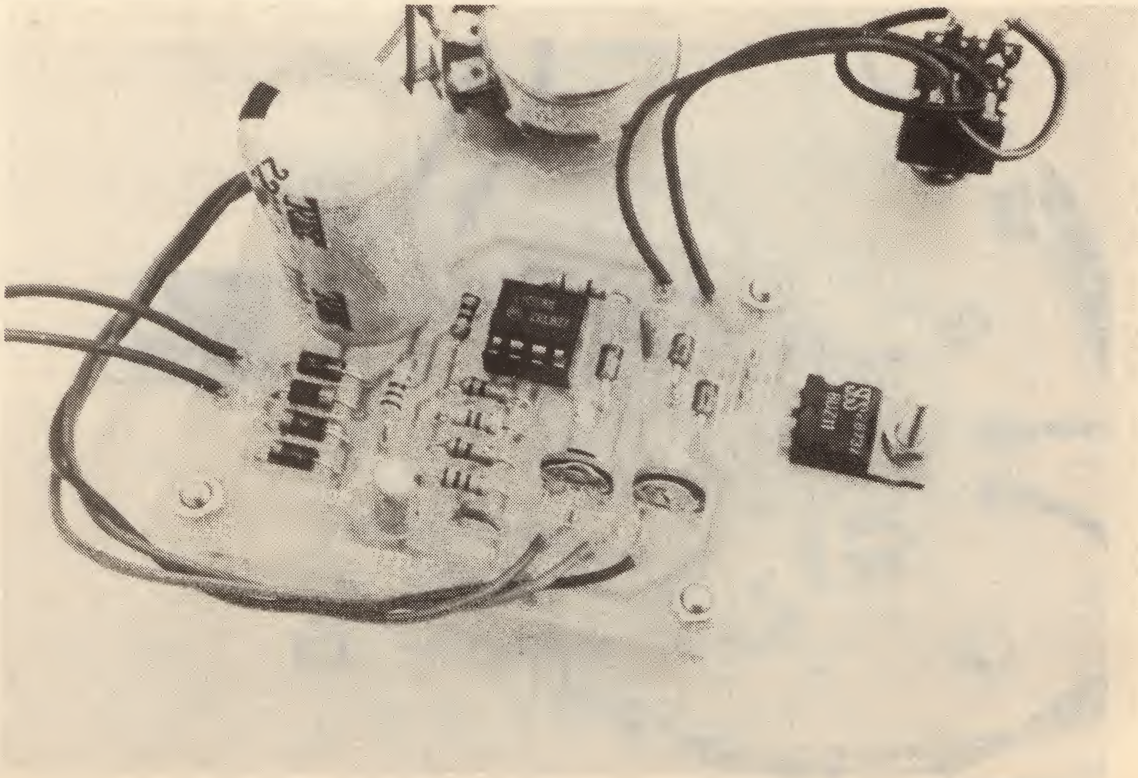
- 1- 10R
- 1- 39R
- 2- 1k
- 1- 47k
- 3- 100k
- 2- 10k Mini Trimpots
- 1- 10k Pot

- 2- 100nF Monoblocks
- 1- 10uF 25V Electro
- 1- 22uF 25V Electro
- 1- 2200uF 25V Electro

- 1- 18V 400mW Zener
- 2- 18V 1W Zener
- 4- 1N4002 Diodes
- 1- BUZ11 MOSFET
- 1- LM358 Op-amp
- 1- 8 pin IC Socket
- 1- Nut and Bolt
- 1- TO-220 Mounting Kit
- 1- DPDT Toggle Switch
- 1- **PWM THROTTLE PCB**

The throttle can handle loads of 1 to 2 amps. There is no provision on the board for adding extra FETs.

The circuit has no overload protection. I have tested the unit into a short circuit with no problems. However I would recommend using a 50W car headlamp bulb in series with



the output of the throttle. The headlamp bulbs are still the best short circuit protection that anyone has come up with for model railways. Just remember that the lamp itself is an overload, so switch off the throttle as soon as you can, then go look for your short circuit.

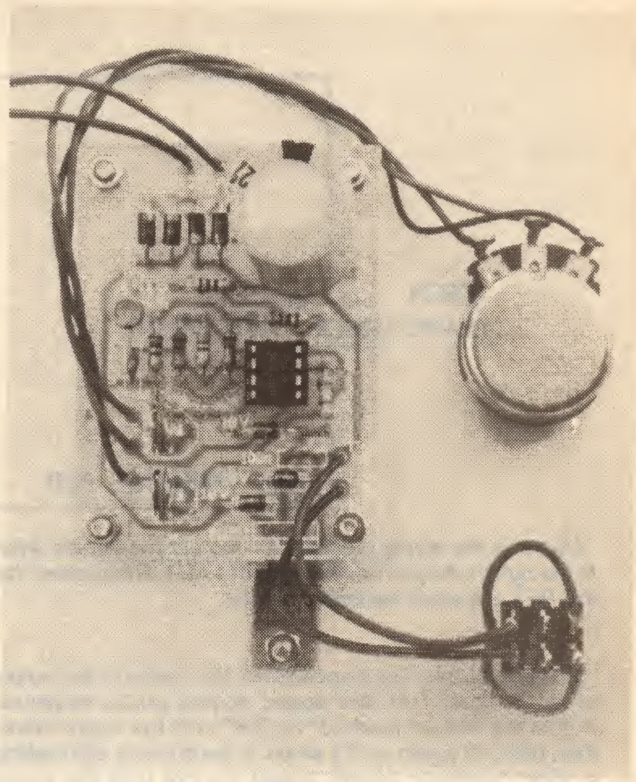
CONSTRUCTION

The throttle is constructed on a printed circuit board measuring 65mm by 48mm. The overlay on the PCB shows component location and orientation. The orientation of the FET is represented by a line through the symbol on the side that the metal surface or tab should face. Zeners are represented by their zener voltage. The size of the zener drawn on the overlay indicates the wattage. The larger symbol is for 1W devices.

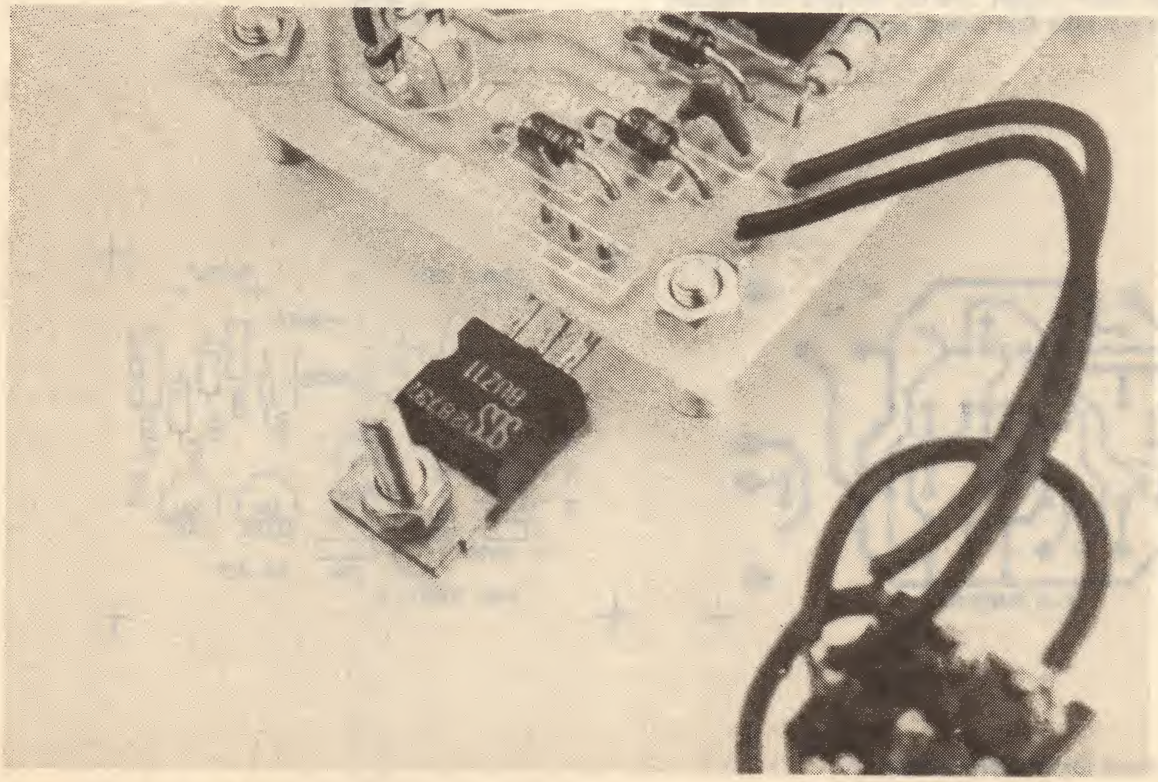
Install all of the low profile components such as the socket, the resistors and diodes, followed by to the taller components. The FET is a static sensitive device and should be handled with care. Make sure that your soldering iron is properly earthed to prevent any static build up on it. It is also a good idea to earth yourself when handling the FET, but if this is impractical, at least touch something that is earthed to discharge any static before handling it.

A heatsink will help keep the FET cool. I mounted my FET from the underside of the PCB so I could bolt it to the aluminium sheet on which I mounted my throttle. Use an insulating kit if you do this. Refer to the wiring diagram when you are wiring the pot and reversing switch.

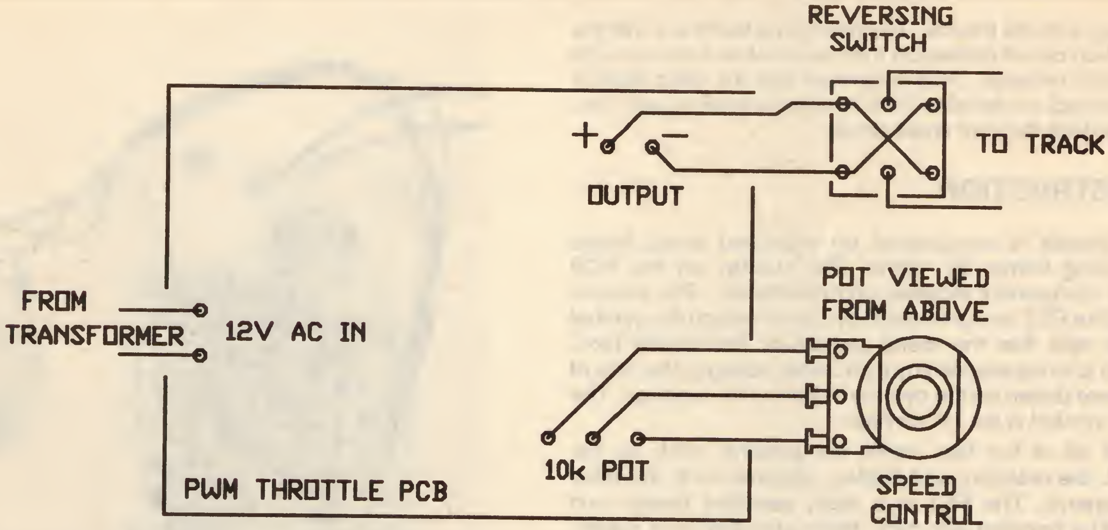
If you wish to experiment with momentum, there is a simple circuit diagram that shows where to connect the components. If you are into computer control, you will have to work out your own interface circuits, as there is no way I can detail all the possibilities.



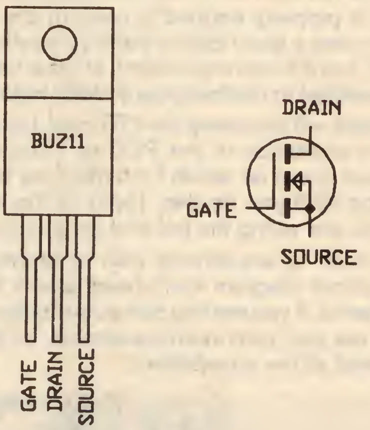
The complete wiring of the simple version of the throttle. The output to the tracks is from the centre two terminals on the switch.



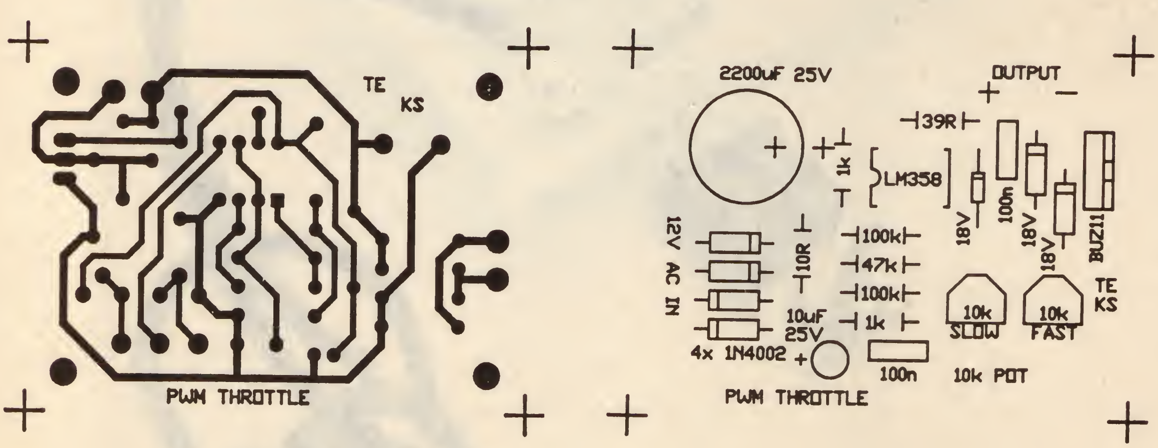
A close up of the FET showing how it is mounted on the sheet of aluminium. Note the use of an insulating kit.



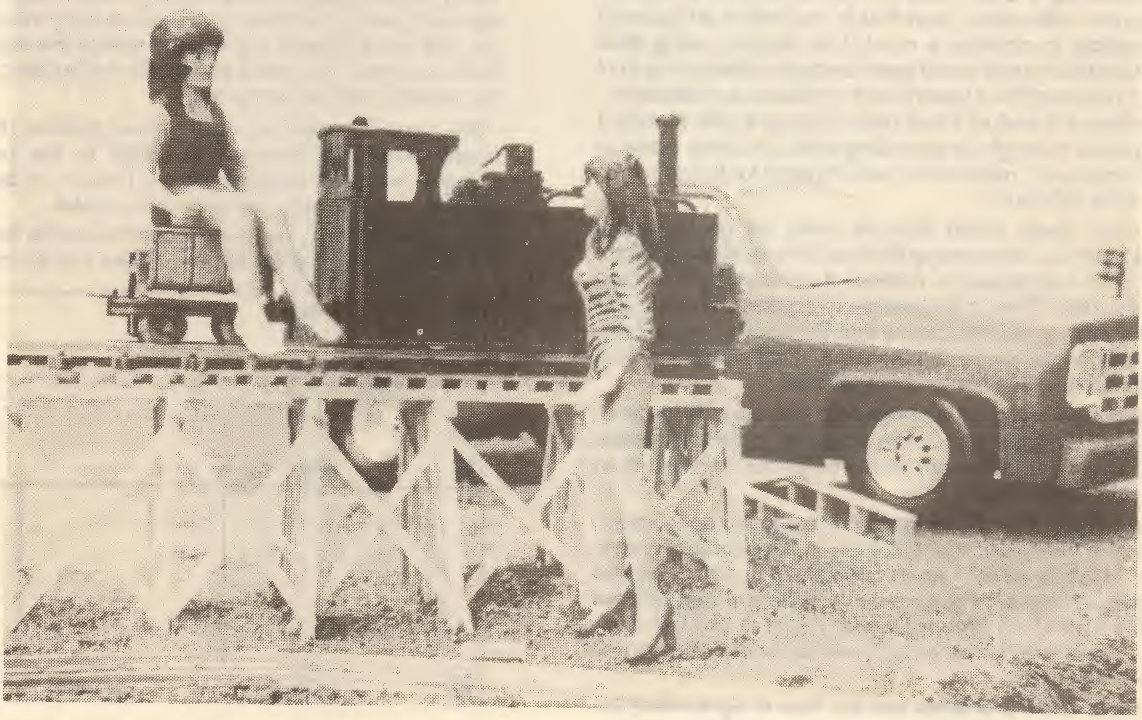
Above is the wiring diagram for the simple throttle while to the right is the pinout of the BUZ11 FET. Remember that the FET is a static sensitive device.



Set up is simple. Connect a small 12V motor to the output of the throttle. Turn the speed control pot to minimum. Adjust the trimpot marked "SLOW" until the motor starts, then back off again until it stops. If the motor is still making a slight humming sound, adjust the pot until the sound stops too. Maximum speed is set using the "FAST" trimpot. Set it to what you find gives you the best range of control with the speed control pot. It does not have to be set to maximum. When you have done this, go back and check the minimum setting again. The two trimpots are interactive, so it is possible that it may now be slightly out of adjustment.



The PC artwork for the PWM Throttle.



What scale do I model? Through the book I have made references to N scale and HO scale. I have modelled in both of these at various times. From the photographs, it should be obvious that I'm into something else! Tressel bridges that go nowhere, bizarre narrow gauge engines and so on. And now this page. Have you ever thought about how you could legitimately combine various scales on one layout? This is my solution. I model miniature railways in 1/25 scale: effectively models of models! In 1/25 scale, 9mm track is very close to a scale 9 inches. So what I have is a 1/25 scale version of a miniature 9 inch gauge enthusiast railway. I can run both my N scale and HOn2-1/2 rolling stock on it at the same time!

Boy, that truck must have tough springs. Either that, or the locomotive isn't a real live steamer!

FIBRE OPTICS

ON MODEL RAILWAYS

In a time when thin glass and plastic fibres are replacing wires in telecommunications, the potential of fibre optics is sure to be noticed by hobbyists. The most amazing thing about these optic fibres is that they can carry light around bends and over great distances, much like wire, yet without suffering from the electromagnetic interference to which wire is susceptible.

However it is not in communications that fibre optics are of interest to a railway modeller, but rather the optical effects than can be achieved using them. Some modellers may have seen the commercial N scale signals made with fibre optics. They looked a lot better that any lamp based N scale signals I've seen. They are not quite as easy to see as the lamp signals, unless you are looking directly at them, but this could be counted as a plus, as real searchlight signals are designed to be directional to stop false reading.

The use of optic fibre doesn't stop there for the railway modeller either. Those of you who built the advertising displays from Electronics for Model Railways volume #1 would no doubt have wished that the displays could have been closer to scale. Those who model OO scale would soon have realized that at three millimetres diameter, a LED becomes a scale nine inches or two hundred and twenty nine millimetres, and that is one hell of a big lamp! It is possible to achieve a much finer display using fibre optics, and the result could even be quite satisfactory in N scale. The optic fibre I used is half a millimetre in diameter. By the time the end of it has been spread a little to stop it pulling back through its mounting hole, it is very close to an OO scale sixty millimetres, exactly right for the common household light bulb.

The optic fibres could also be used for other simple effects, such as illuminating the torch of a night watchman, miner or a maintenance worker. If enough light is sent down the optic fibre, it is possible to achieve a beam. It is not very strong, but will cast a definite spot on something a few millimetres away. So the scale night watchman has forgotten to replace his torch's batteries...

Scale lamps could be arranged on the front of locomotives. Car headlights would be possible, even in N scale. In HO scale, car indicators would be easier to make than if you had to file down LEDs.

There are still a couple of problems using the optic fibres, and one of them is that any display is directional. In other words, unless you are looking directly at it, you can't see the lights. This can be overcome by putting a matt diffuser over the end of the fibres. Tracing paper or matt drafting film will both work. You could even try some non waxed lunch-wrap paper.

The other main problems are the loss of light down the length of the lower quality plastic fibres, and how to convince the light to go down the fibre in the first place.

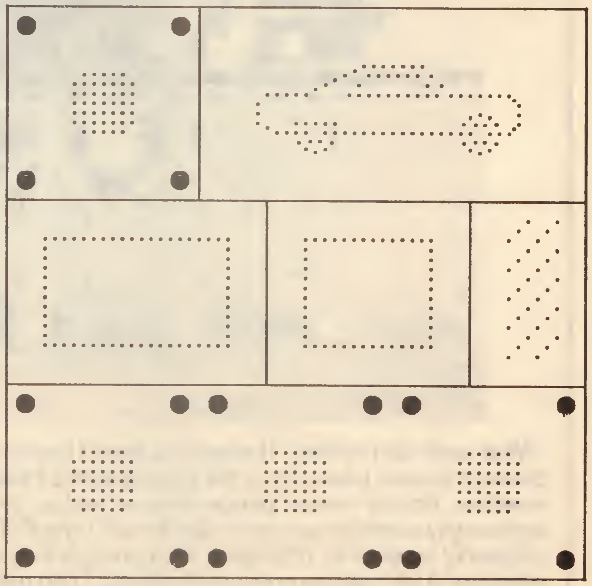
Due to the losses in the fibre itself, LEDs really are not bright enough to drive them. Some success can be had if the fibres are fairly short. Lamps are a much better proposition. You are not limited to grain of wheat bulbs either, as these lamps are going to be hidden under the layout. The small bayonet based 6W lamps, sometimes used for illuminating automotive licence plates, work well. Another problem does arise though. Without proper ventilation for the lamps, it is possible to melt the plastic fibres!

How do you mount the fibres? In the case of a simple advertising sign, fine holes are drilled in a piece of printed circuit board or polystyrene sheet plastic where required. A second piece of board or plastic is also drilled with the same number of holes, but in a different arrangement. This time the holes are arranged so that they are grouped in clusters, one for each lamp being used to drive the sign.

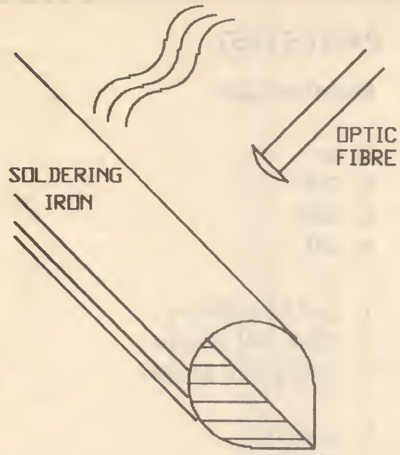
For this example, we will consider that the sign is to be mounted in the window of a plastic model shop, and that the lamps are going to be put under the layout, on the other side of the chipboard on which the building is to be mounted. First a sizable hole will need to be drilled to pass the fibres through. It is better to drill a hole that is too big because trying to enlarge it later will be impossible, and trying to drill a second hole is risky, as it would be easy to slip and destroy the fibres you have already installed. First you will need to work out exactly where the sign is going to be mounted. You can't attach it to the building, because the building will get in the way.

When you have worked out it's exact position, the display board should be securely mounted to the base-board using a couple of small brackets. These can be made of printed circuit board, plastic or even metal.

Once that is done, you can mount the boards that will hold the fibres in front of the lamps. These can be mounted in



The artwork for the display boards. It can be made of any material. If you use plastic, take care not to melt it with your lamps.



Use a hot item such as a soldering iron to flatten the ends of the fibres. Do not actually touch the fibre with the iron. Let the radiated heat do the work.

several ways, depending on which you feel the most suitable. They can be mounted at right angles to the bottom of the base board using brackets. Alternately, if you wish to drill three large holes in the base-board, you can fix the lamp boards directly over the holes, saving yourself the effort of making brackets. The fibres will be shorter this way too, but there is more chance that the light from the lamps will leak into the building itself, through unused holes in the lamp boards.

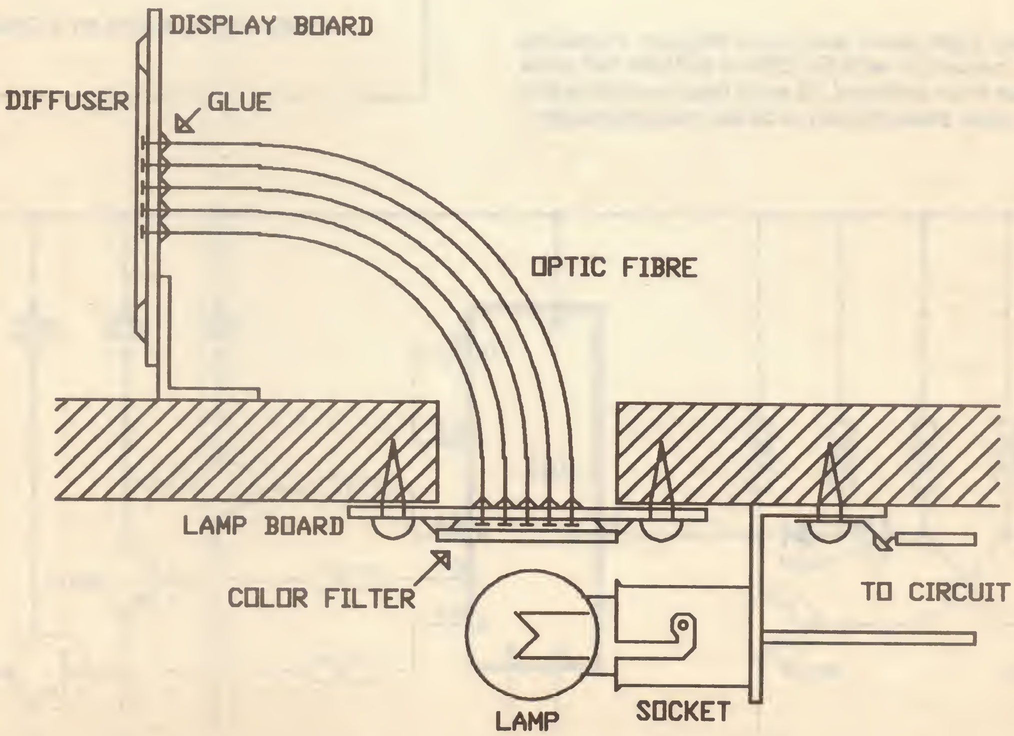
Now that both boards are securely mounted in their final locations, a length of fibre is passed first through the hole on the lamp board then run up to the display board and through the correct hole.

Now you need to stop the fibre from pulling back through the hole. If you hold the end of the fibre close to the side of your soldering iron, it will flatten out or thicken, depending on the fibre. Take care not to touch the iron. Also try to make the "knobs" on the ends of all the fibres the same. Now pull the fibre back so that no excess is sticking out from the front of the display. A small dab of glue can now be applied to the back of the display to hold it in position. Test your glue first. It must not react with the plastic of the fibre. PVA or "white" glue is suitable. You may like to leave the gluing step until you have a few fibres ready, to save time and effort.

Be careful not to pull the fibre too tight around any sharp corners, as it will break. With most of the slack removed, snip the fibre off in the other side of the lamp board, and once again hold the soldering iron near it to flatten its end. Glue the fibre where it passes through the board near the lamp. The process is fairly simple, but repetitive. You will have to do the same thing for every other fibre in the display.

The board artwork given is for a three step running light pattern, much like the ones done with LEDs in the Shop Displays Article in the last book. In fact the circuit can be used to drive this display. Replace the transistors with more suitable ones if you choose to use heavier lamps. Either BC338's or BD139's would do the job. BD139's can be heatsinked, which may be advantageous.

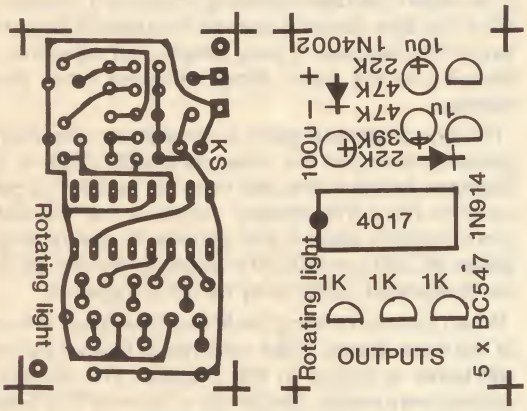
When you are running the fibres, take them in turn to each ot the three lamps. Take care not to foul up the order as it will leave a hiccup in the display. The display can be colored very easily. Simply slip a colored filter between the lamp and the ends of the optic fibres.



This is how you could set up the lamps and dispay boards. Of course, if you are making a running light display, there will be three lamps. The rectangular display boards are arranged so that the number of holes can be divided by three so that the pattern will look correct.

The exact shape and size of your display will depend on where you plan to mount it and what you intend to advertise. The artwork I have provided includes two simple rectangular signs, an angular pattern and a stylized car. With the latter, I illuminated the outline of the car with one constantly lit lamp, and used the three step sequencer to make the wheels look as if they were rotating. It's a great way to indicate the entrance to an underground car park. As the wheels of the car require few fibres, there are plenty of spare holes left to drive another of the signs. The car can be made facing either direction too.

When you have finished running all the fibres, the shop building can be positioned over the display again. If you find you require a light shield inside the building, one can easily be made from some opaque cardboard. Light shields will also be needed between the lamps under the layout.



The rotating Light board and circuit diagram. Replacing the output transistors with BC338s or BD139s will allow larger lamps to be switched. As each lamp is on for only a third of the time, there should not be too much dissipation.

PARTS LIST

Rotating Light

3- 1k
2- 22k
1- 39k
2- 47k

1- 1uF 16V Electro
1- 10uF 16V Electro
1- 100uF 25V Electro

1- 1N4002
1- 1N4148
2- BC547 Transistors
3- BC338 Transistors
1- 4017 Decade Counter

1- 16 pin IC socket

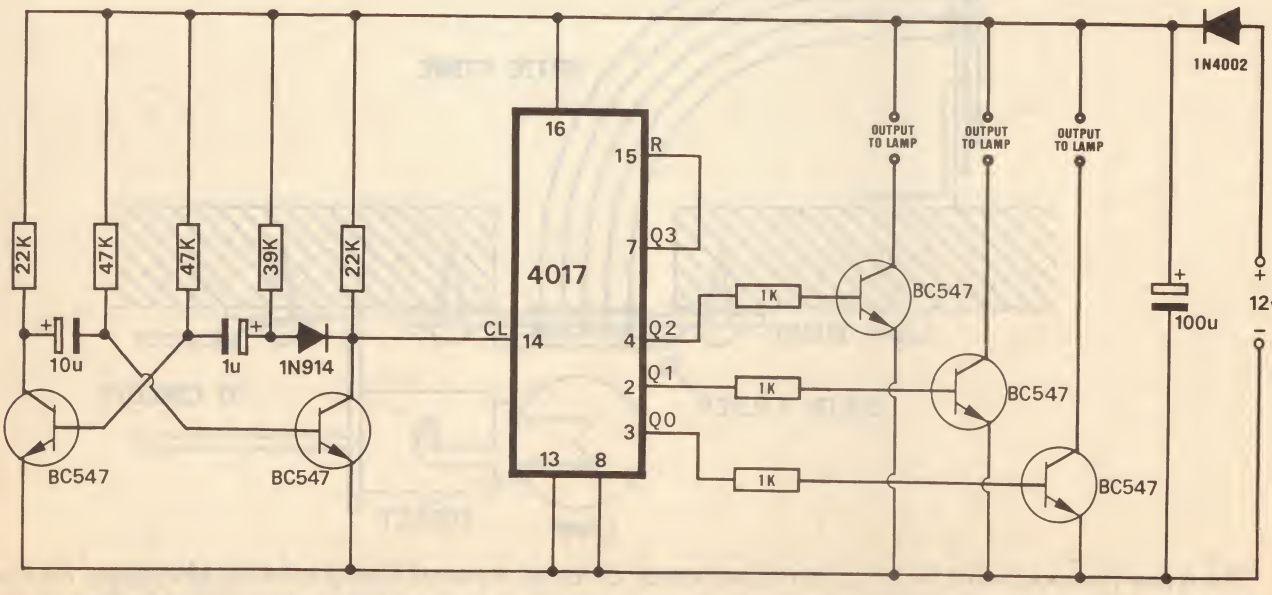
1- **ROTATING LIGHT PCB**

PARTS LIST

FIBRE OPTIC DISPLAY

10 metres of 0.5mm Optic fibre

FIBRE OPTIC DISPLAY BOARD



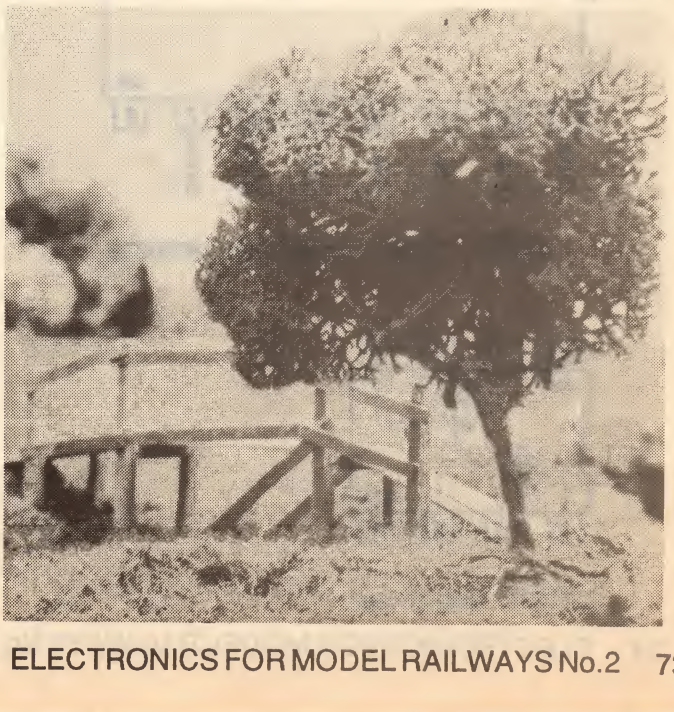
TREES

Now, what is an article on the construction scale trees doing in a book on electronics? I suppose you could ask the same question about the miniature street signs at the back of the last book too. It is just that the electronics hobbyist has at his disposal some of the best tree making materials and tools that I can think of. Copper wire, solder and a soldering iron. As commercial trees are often expensive, and sometimes look rather unrealistic, it is better to build your own. That way you can have a tree that is exactly the shape and size you want. A forest won't cost you as much as a brass locomotive either!

The best wire to use is the multi-stranded wire that is found in heavy automotive or mains flex. After a suitable length has been stripped, several bunches are twisted together to form the trunk. Apply just enough solder to the trunk to stop it falling apart. It is now possible to make branches by separating smaller bunches and twisting them. Each of these bunches are then split into smaller bunches and twisted. Keep doing so until the branches end as single strands. If you are not quite sure of where to make the branches, go out and have a look at a real tree.

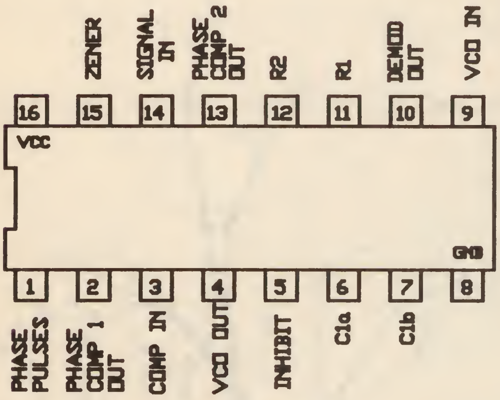
The roots are made in much the same way, except that the wires should be kept a lot shorter. Keep the centre of the root structure clear so that when you finish the basic structure of the tree you can solder a wood screw or nail at the bottom of the trunk. This makes mounting it on your layout a lot easier and more secure than some of the commercial ones that tend to fall over even if you try to glue them to the baseboard. When you are satisfied with the structure, apply more solder, filling in the wire so that the trunk and branches look solid. When you have finished the soldering, scrape any excess resin from it as it tends to react with paint, leaving an unwanted gloss finish.

The tree can now be painted brown or white, depending on the type you are modelling, and the usual lichen, chopped foam or what-ever foliage can be added while the paint is wet, or stuck on later using glue. Trees made this way are quite realistic, and cheap. If you want a forest, there is no other way to go!

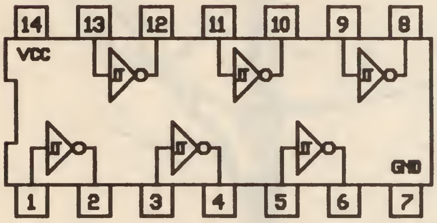


Two examples of trees built using this method. One is capped with lichen, the other is yet to receive any folliage. It still looks effective without leaves, making it suitable for modelling winter scenes.

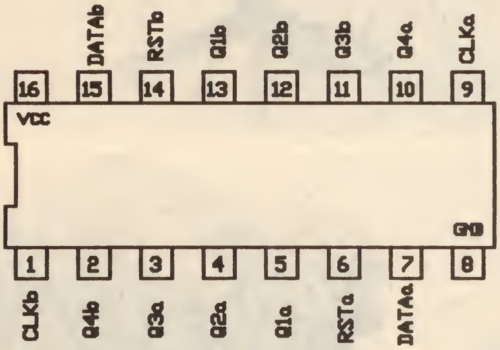
DATA



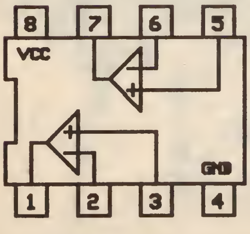
4046 PHASE-LOCKED LOOP



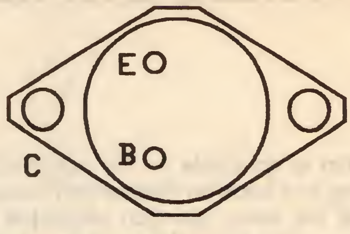
40106/74C14 HEX SCHMITT INVERTER



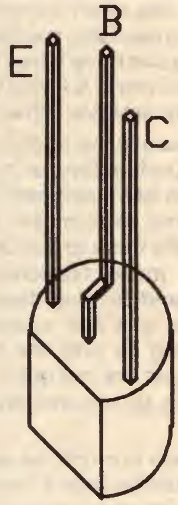
4015 DUAL 4 STAGE SHIFT REGISTER



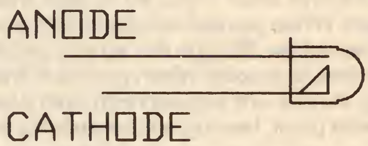
LM358 DUAL OP-AMP



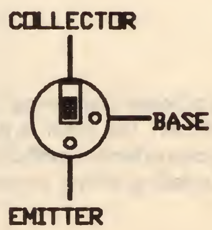
The 2N3055 viewed from below.



An enlarged view of the TO-92 transistor package showing Base, Collector and Emitter leads. The BC547, BC557 and BC338 are all in this package.



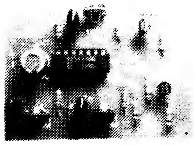
The connections to an LED. The cathode is usually indicated by a short lead and a flat on the flange at the bottom of the LED body.



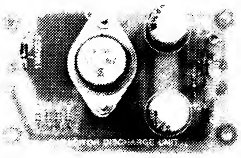
The pin-out of the MEL12 phototransistor when viewed from above. The base lead is not used in any of the circuits in this book.

KITS FROM BOOK 1 ELECTRONICS FOR MODEL RAILWAYS

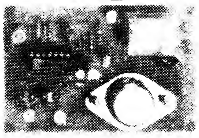
Air Horn & PC $12.90
PC board only $3.75
A triple air horn to add realism to your shunting yard.



Capacitor Discharge & PC $10.20
PC board only $3.85
This project will switch your points and wont burn them out. Can handle a number of points, one at a time.



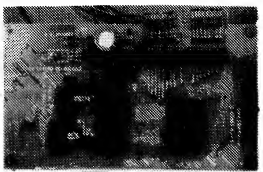
Crossing Boom Control & PC $18.70
PC board only $3.75
This project will operate boom gates and needs to be combined with Level Crossing and Crossing Sound to be fully operational.



Crossing Expansion & PC $17.80
PC board only $3.55
This module is added to Level Crossing if your layout spans 4 tracks.

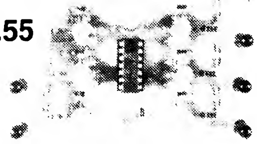
Crossing Sound & PC $14.90
PC board only $3.45
This module is added to Level Crossing to achieve the bell sound for a boom-gate crossing. The sound is really effective.

Dedicated Micro I & PC $51.90
PC board only $11.05
This simple micro computer is presented in books 1 & 2. The ROM contains programs for a fully controlled intersection including pedestrian traffic.

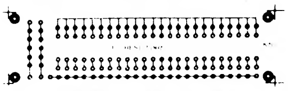


Fluroescent Simulator & PC $9.80
PC board only $3.55
This project simulates the starting or flickering of a faulty fluorescent lamp. Adds realism to your layout.

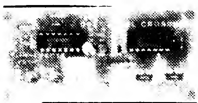
Hex Train Sensors & PC $22.55
PC board only $3.85
Six sensors that can be placed around your layout to detect the presence of a train.



LED resistors & PC $4.15
Designed to be used with Light Sequencer.

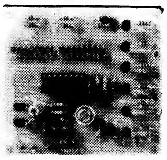


Level Crossing & PC $16.70
PC board only $3.55
Create realistic level crossings for train and road traffic.

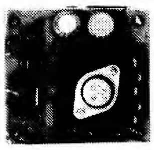


Light Sequencer & PC $23.30
PC board only $4.60
Create programmable lighting sequences.

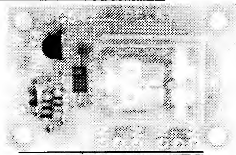
Pedestrian Crossing & PC $17.70
PC board only $4.55
A simple Pedestrian Crossing project.



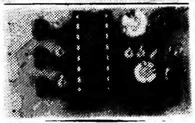
Power Supply & PC $16.15
PC board only $4.15
A 1 amp or 2 amp power supply that can be adjusted from 5v to 15v.



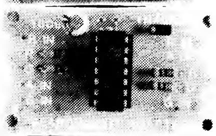
Remote Relay Unit & PC $6.35
PC board only $2.10
A buffered relay for use around your layout. A useful building block.



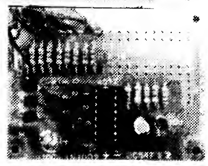
Rotating Lights & PC $8.20
PC board only $2.20
Adds impact to accident scenes etc.



Searchlight Adaptor & PC $4.45
PC board only $2.10

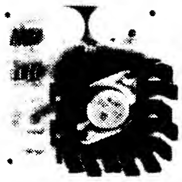


Shop Display Driver & PC $11.75
PC Board only $4.05
Create miniature running light displays for shops etc.



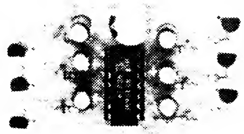
Shop Display PC board $6.00
This is a double-sided PC board containing 7 different displays. You will need to buy red, orange and green LEDs to make the displays.

Throttle & PC $15.65
PC board only $3.60
A simple single-board DC throttle.



Train Detector & PC $17.85
PC board only $4.35
5 train detectors on a PC board detect the presence of a train at 5 locations.

Warning Lamp Unit & PC $11.30
PC board only $3.45
Create flashing lamps for scale construction sites, roadworks etc.



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